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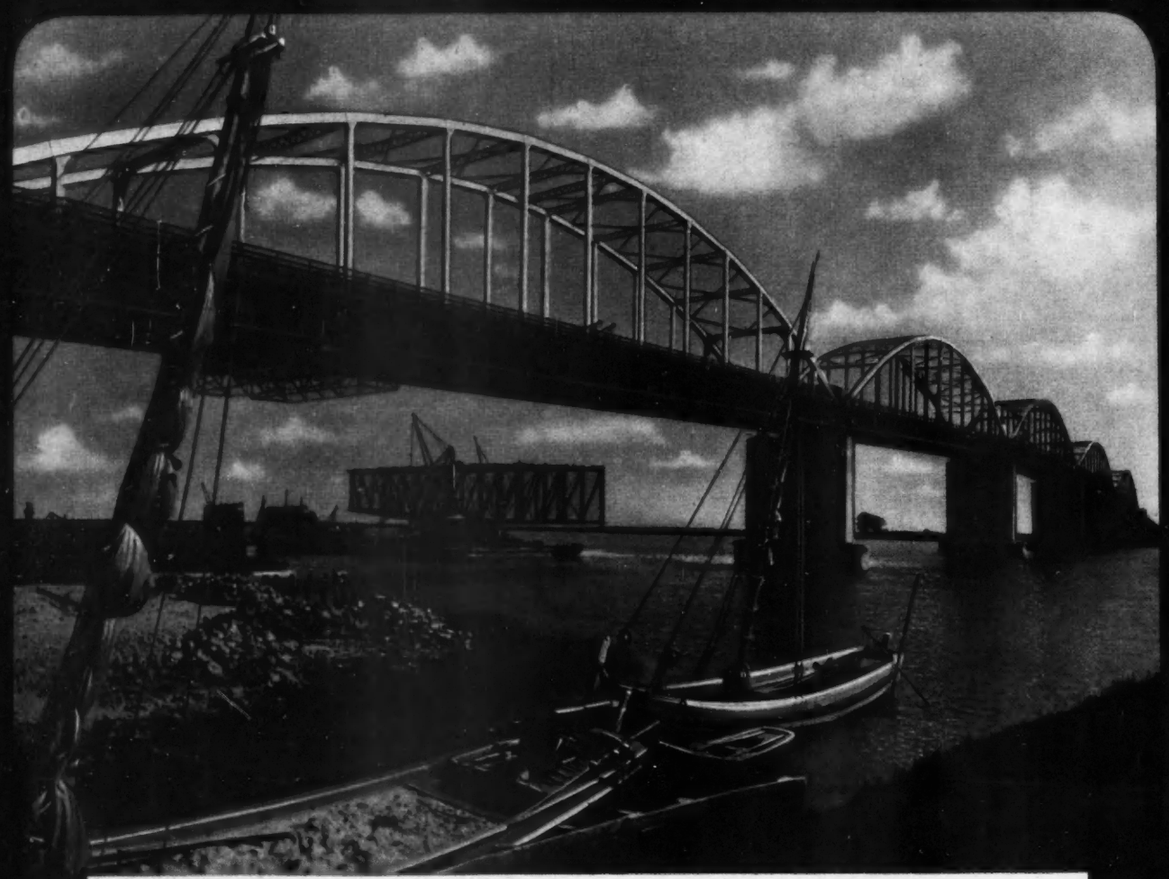

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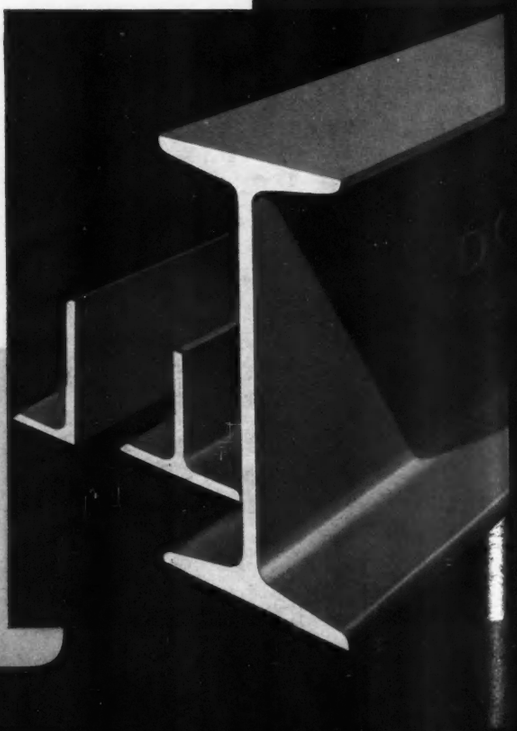

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Leading Article
Machinery from Abroad 129

Principal Articles
Britain's Greatest Engineering Market: 1—Australia's Growth and Needs 132
Effect of Boiler Capacity on Locomotive Performance 138
Research and Training in Work Study: The Laboratory at Cranfield College 140
Bare Conductors for Generator-Transformer Units 143
Auxiliary Electric Power: Diesel-Driven Plant at Aircraft Works 148
Switch for Heavy Current Testing: Low-Voltage Transformer Work 150
The Production Exhibition 151
An American Steam-Turbine Locomotive 153
Design of a New Shipyard: Prefabrication in Shipbuilding 154
128-MW Power Station at Rye House: Unit System with Pulverised-Fuel Firing 156
Ignitron Contactors for Large Currents: Electronic Switch Provides Weld-Heat Control 158

Weekly Survey
The Potential of Australia 130
V.H.F. Sound Broadcasting 130
Cotton Spinning Capacity 130
Gatwick Airport Inquiry 130
Motor Vehicles and Trade 130
Aircraft for B.O.A.C. 131
Pre-Cast Prestressed Concrete 131
Proposed Royal Colleges 131
A "Power Station" Locomotive 131

Contracts 134

Obituary
Sir Herbert G. Williams, Bart., M.P. 134
Mr. J. L. Adam, C.B.E. 134

Personal 135

Business Changes 135

Book Reviews
Applied Heat and Heat Engines 136
Garcke's Manual 136
Electric Traction Handbook (Control) 136
Oil in the Middle East: Its Discovery and Development 136
Sponge Iron and Direct-Iron Processes 137

Trade Publications 137

Books Received 137

Launches and Trial Trips 150

Forthcoming Exhibitions and Conferences 159

Labour Notes 160

News
Machines Dangerous to Young People 133
Impulse Tests on 275-kV Transformers 133
Tubular Framework for Racing Motor Boat 135
The World's Shipbuilding 136
The Institution of Electrical Engineers: Elections to Council 136
Measurement of Small Currents and Voltages 139
Window Control: Use of Flexible Cables 148
New Cable Factory 148
Rubber in Liquid Form 149
Electricity Supply in June 149

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MACHINERY FROM ABROAD

THE duty-free admission of machinery and plant into the United Kingdom was acknowledged as a difficult long-term problem by the Chancellor of the Exchequer in his Budget speech of March, 1952, when he announced that licensing would be stopped and the problem examined "in consultation with industry." Until that date machinery worth £120 millions had been admitted free of duty since the end of the war, constituting just under one-third of the total imports of machinery by private industry. A committee was appointed under the chairmanship of Sir Henry Wilson Smith to consider whether it was in the national interest to resume duty-free imports "of machinery, either by classes or individual consignments." The committee, who reported last week, conclude that "some discretionary system to permit the duty-free entry of machinery in suitable cases is in the national interest"; and that the scope of the scheme should be broadened to include plant. They found it impossible to draw up a list of easily identifiable types of machines or plant and recommend that each application should be considered on its merits, and that none should be admitted that relates to a consignment worth less than £2,000. The committee were pre-occupied with three major considerations: those of productivity, protection and administration.

The first consideration, that of productivity, lay in assessing the effect on British industry of having to pay more for certain machines, generally specialised and often very costly, than their foreign competitors through the imposition of a 20 per cent. import duty by the British Government. The committee's investigations led them to conclude that the duty has had relatively little effect on the volume of imports and that if a manufacturer really needs a foreign machine and can afford it "he will import it whether he has to pay duty or not," but that "we cannot lightly disregard the impact on costs of an additional 20 per cent. on even a small proportion of the capital expenditure of United Kingdom industry which is fighting for its existence in increasingly competitive world markets." At best the duty will add to production costs; at worst it (or the difficult and lengthy application procedure) may check the very legitimate desire of the enterprising manufacturer to experiment with new types of machines as soon as they become available.

The second consideration, that of protection for British machinery makers, appears to have loomed large in the committee's collective mind; perhaps unduly so, for in their own words "imports of machinery represent only a small fraction of United Kingdom production and not a large fraction of United Kingdom exports of machinery". The applicant for a duty-free licence is obliged to justify his application on the ground that no machine of similar performance and design is available within a reasonable period in this country. The committee do not appear to have considered whether or not unhindered competition from foreign machinery makers might not act as a stimulant to British makers, both in respect of design and costs. Their basic assumption is that protection rather than competition is in the national interest. However desirable protection may be to foster the growth of a young industry, its desirability may be questioned when it relates to the oldest established and largest engineering industry in the world, and more particularly to an industry which depends for expansion and prosperity on a rising level of exports. On the whole, the need for protection would not seem to be very adequate justification for a scheme which, despite the most careful study, will involve heavy administrative expenditure, frustrating delays in the granting of licences and, as in the past, "frequently long drawn out discussions and arguments."

The third major consideration of the committee was to recommend a workable scheme for duty-free licensing. The burden of considering on their merits upwards of 1,000 applications a month – the rate at which they were being received in 1951 and 1952 – was extremely heavy and was considered too high a charge on the taxpayer to be in the national interest. The committee have therefore raised the qualifying minimum at which an application may be accepted for consideration from £50 to £2,000, below which fell 60 per cent. of all applications received. There is little to offend in the committee's recommendations for the administration of the licensing scheme. It will be operated by the Government departments concerned, with the help of a consultative committee containing representatives from industry. Plant to be included in the scheme was defined by the committee as "broadly speaking, static equipment which performs industrial processes by non-mechanical means" (after the Federation of British Industries, the National Union of Manufacturers, and the British Engineers Association had failed to agree on a definition). The Wilson Smith Committee's report is well presented and excellently argued, but its major premise – that protection is necessary or desirable for British machinery and plant makers – is open to challenge from those who have the interests of British engineering as a first consideration.

Weekly Survey

THE POTENTIAL OF AUSTRALIA

The importance of the Australian market to British engineering is greater than is generally appreciated, even after the stunning effect of the import cuts imposed by the Australian Government in 1952. In the first five months of the current year she accounted for over 10 per cent. of total United Kingdom exports and for 11½ per cent. of United Kingdom exports of metals and engineering products. Even more important, a major proportion of the rise in British engineering exports was due to an increase in exports to Australia (see "Motor Vehicles and Trade"). For this reason we are publishing two articles in order "to assess the importance of Australia to British engineering and to show what, in the economy of the country, influences demand for British engineering goods." The first article, which contains an analysis of the source and nature of Australian needs for engineering products, and a discussion of recent trends of capital investment, appears in this issue of ENGINEERING.

One important conclusion reached in the article is that Australia is for the second time since the war drawing near to the point where any fall in export earnings could lead to a national crisis. Another is that wool is the main (over half the total) and so far the only stable export. "Overall the trade situation requires careful watching, as any weakening in the price of wool must mean drastic cuts in imports which are likely to be even more swingeing than those which enabled Australia to ride the 1952 crisis."

The second article, appearing next week, will describe and analyse the growth of primary industry, such as agriculture, wool, coal and the newly-found oil, developments in the provision of services such as transport, irrigation and electricity, and the growth of secondary (i.e. manufacturing) industry, which includes a large and rapidly developing engineering industry.

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V.H.F. SOUND BROADCASTING

The first stage of a scheme for sound broadcasting on very high frequencies, which, it has been announced by the Postmaster General, may now proceed, will involve the erection of nine transmitting stations each of which will radiate the Home, Light and Third programmes. These stations will use frequency modulation and will employ frequencies in the 88 to 95 megacycle band. Those at Wrotham in Kent, Norwich, Sutton Coldfield and Holme Moss will have an effective radiated power of 120 kW and those at Pontop Pike, near Newcastle; Divis, in Northern Ireland; Meldrum near Aberdeen; and two others in South Devon and West Wales a power of 60 kW. This is only about half the number suggested by the British Broadcasting Corporation.

There are already two transmitters at Wrotham which have been giving an experimental service since 1950. A third transmitter is, however, to be installed and will be regularly operated from May, 1955. The other eight stations will, it is expected, be completed during the following 18 months. They will be erected on the same sites as the existing television stations and will use the same masts. It is hoped that the stations at Pontop Pike and Divis will enable the long-standing problem of shared wave lengths, which makes it necessary for the medium-wave transmitters in north-east England and Northern Ireland to carry the same programme, to be overcome. The new network is intended primarily as a reinforcement of the existing long-wave and medium-wave services and should make it possible for all three programmes to be received without interference in many areas where at present reception is spoiled by fading, especially after dark in the winter months. The industry is expected to produce the receivers and adaptors in time for the opening.

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COTTON SPINNING CAPACITY

Details of world cotton-spinning capacity issued by the International Cotton Federation last week show that post-war expansion has largely taken place among competitors or in traditional markets of the Lancashire cotton industry. This loss of ground by Lancashire has naturally had repercussions on the British textile-machinery industry. A high proportion of the total market now lies in those areas in which Japanese manufacturers (who also have the benefit of a large home market) are in a strong competitive position. Japanese machinery is often cheaper than the British, and not necessarily always inferior in quality. The main disadvantages, according to a recent report of the Japanese Ministry of International Trade and Industry, are the poor service facilities and the high price of parts. This has not, however, prevented Japanese manufacturers from gaining large orders in India and Pakistan, and it is a source of credit to British manufacturers that they have been more than holding their own. Chinese orders are not, of course, likely to go to Japanese manufacturers and, together with the large Russian orders already received, may go far to restoring the depleted order books of British textile machinery manufacturers.

World demand for cotton textiles, having recovered from the slump of 1952, is again at a high level. The continued increase in cotton-spinning capacity, which has caused some alarm in recent years, has therefore attracted little attention. The rise of 110,000 in the number of spindles in place in all countries, to a total of 129·44 million in the year to January, 1954, is not in itself very impressive, and is much less than in previous years; but the aggregate totals conceal a far-reaching change in the structure of the world cotton industry. Whereas European, including British, capacity has been falling – by 677,000 spindles in the six months to January, 1954 – Asian capacity has been rising. Japanese capacity rose by 264,000 spindles and Indian by 294,000. Moreover, of the new world capacity (exclusive of replacements) under construction in January, amounting to 826,000 spindles, 550,000 were building in Asia, including 290,000 in India and 167,000 in Korea. Recently it was reported that two new mills totalling 100,000 spindles were to be erected in China and some existing mills expanded.

These trends follow inevitably from the character of demand for cotton textiles. The large Eastern demand is naturally for cheap textiles, which Lancashire is finding it difficult to manufacture competitively, and Japanese cloths are now being admitted in increasing quantities to the African Colonial markets in which Lancashire has hitherto enjoyed a high degree of protection. Exports of British cotton piece goods to British West Africa, for example, were down by about 30 per cent. in the first quarter of 1954. Shortage of labour, relatively high labour costs, and the shorter machine hours worked make it unlikely that Lancashire can ever again capture the mass market – although, of course, it should always be possible to maintain a large turnover in higher quality cottons. It is worth noting, too, that the number of British spindles spinning staple fibre increased sharply from 2·52 million to 3·81 million in the six months to January, 1954.

GATWICK AIRPORT INQUIRY

The "Report of an Inquiry into the Proposed Development of Gatwick Airport" (H.M. Stationery Office, 2*s*.) gives the findings of Sir Colin Campbell, O.B.E., who was appointed in January by the Minister of Housing and Local Government to hold an inquiry on local objections to the proposed development. The terms of reference excluded comparison with possible alternatives to Gatwick and this, Sir Colin considers, has limited the usefulness of the inquiry.

An explanation of the Government's overriding, in 1951, of earlier assurances that Gatwick should remain a small airport has, however, emerged: owing to the international situation, Stansted, which had been intended as an alternative airport for London, had had to be developed for military aviation. For air traffic control reasons, the Ministry of Civil Aviation considered it essential that the airport should be sited between the Air Traffic Lanes known as Amber 1 and Amber 2; and, Sir Colin comments, "if a site must be found between them . . . it is difficult to see how any other site can be found better suited to requirements than Gatwick. . . . But the Surrey County Council contend that Amber 1 and Amber 2 are Traffic Lanes designed to fit into a given pattern of airports, and that the technical officers of the Ministry of Civil Aviation can, if another site is chosen, work out a satisfactory control pattern for it and for the other aerodromes in the area." Sir Colin, while considering that the Ministry of Civil Aviation had established that Gatwick was a "suitable" site, suggests that further consideration should be given to this matter.

Among the objections raised during the inquiry was a criticism of the smallness of the Gatwick site, and the Ministry admitted that the distance between the two projected main runways was smaller than is desirable. The objectors submitted that a new airport should not be constructed which would not allow for considerable extension, and Sir Colin finds "considerable substance in this criticism."

If the Government decide to proceed with the scheme, Sir Colin states, the question of safeguards and conditions requires consideration, as does also financial hardship arising from the Government's change of mind. Another question requiring further consideration is the diversion of the London-Brighton road (A23). The Ministry's proposal is for the shortest possible alternative to the part of the road passing through the land required for the airport. If the road were diverted further east, it could be designed as part of the projected London-Brighton radial road. This would save abortive expenditure of £212,000 and would avoid having to tow aircraft across the main road.

Sir Colin calls attention to the absence of early consultation of the Ministry of Civil Aviation with the local authorities concerned, who "properly resented the fact that a scheme so seriously affecting their areas should have been developed so fully without their being brought into consultation . . ." and expresses the hope that in future the Ministry will seek the views of the local authorities much earlier.

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MOTOR VEHICLES AND TRADE

Last week the motor vehicle industry announced a record output for the first six months of 1954: 380,000 cars came off the production lines at the rate of one car every 11 seconds of the working day. Total output of all motor vehicles was 508,000, 27 per cent. more than in the first six months of 1953. This performance should enable the industry to produce a million vehicles this year for the first time in its history.

The high level of output was due partly to the buoyancy in world trade which carried total British exports of all goods for the six months to £1,344 million, 7 per cent. higher than in the same period of 1953, and about as high as in any previous half-year since the war. Engineering exports rose by about £36 million, so they contributed well over a third of the total increase. Half of this in turn was due to the increase in motor vehicle exports, which rose to £141 million.

Present prosperity inspires confidence in the future, but it is worth examining the basis upon which it is founded. Much of the increase in British exports has been due to the relaxation of import restrictions in sterling countries, particularly Australia (which accounted for 62 per cent. of the increase in British car exports). As an article in ENGINEERING this week points out, it may be difficult for Australia, due to weaknesses in her own export trades, to maintain imports at the present level, particularly if wool prices should fall. Trade with the dollar area has already fallen off. The reduction of 7 per cent. in British exports to dollar countries in the first six months of 1954 is smaller than might have been expected as a result of the recession in the United States. There is, however, as yet no clear indication that the recession is over, and surprisingly enough, exports to Canada have suffered more than exports to the United States. Exports of cars to the U.S. fell by 19 per cent., but those to Canada fell by 42 per cent. One of the most encouraging features is the rise in exports to Western Europe, achieved against increasing German competition. Some of this was, however, due to better trade relations with Sweden; because more Swedish goods are being imported by the United Kingdom, Swedish import quotas for British goods have been increased and twice as many British cars are being admitted as in 1953.

The high volume of exports must not be allowed to obscure the extent of the motor vehicle industry's dependence upon the home market. In the first six months of 1954 the export percentage for cars actually fell to 49·5 per cent. from 54·6 per cent. the year before. Deliveries to the home market have averaged about 32,000 cars a month so far this year, which compares with 21,300 a month in 1953 and 14,400 a month in 1952.

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AIRCRAFT FOR B.O.A.C.

British Overseas Airways Corporation made a profit of £311,000 on the quarter from March 31, 1954, even with the upset to their services by the withdrawal of the Comets. This confirms the belief that rich rewards are likely when jet aircraft are re-introduced on regular services.

Unfortunately, despite the progress made in tracing the presumed fault in the Comet I, it is clear that it will be some time before this aircraft or the Comet II, now nearing the end of its flight trials, can go into service. The prototype of the Comet III has now made several successful flights and, with its capacity for 58 first-class and 76 tourist-class passengers, will greatly reduce operational costs; but it is unlikely to be in service in less than two years. The Bristol Aeroplane Company have overcome the setbacks which the Britannia suffered at the prototype stage, and the first of the 33 on order for B.O.A.C. are expected to be delivered by the end of the year. Even so, B.O.A.C. have found it necessary to buy 15 piston-engined Boeing Stratocruisers and Lockheed Constellation 749 airliners. Since it takes roughly two piston-engined aircraft to give the same service as one Comet, these will do little more than replace the six grounded Comets and permit B.O.A.C. to restore curtailed services such as that to South America.

The cost of the replacement of the Comets by piston-engined aircraft is high. The price paid for each is not likely to be much less than £500,000, and it seems that all but four – purchased from Qantas Empire Airways – are being obtained from dollar sources. B.O.A.C. may, of course, be able to recover a high proportion of the purchase price, when it becomes possible to dispose of the aircraft. They have announced their intention of selling the seven Stratocruisers when Britannias become available and the Constellations when Comet services are resumed.

This reversion to piston-engined aircraft may, however, be costly in other ways. The first United States jet airliner (the Boeing 707) has now flown, so that U.S. manufacturers who were formerly well behind the British in jet development are now likely to have aircraft which will be ready for service at least as soon as the Comet III. It must be remembered, of course, that the presumed defects of the Comet I developed only after two years' flying, and that it is therefore still premature to speculate about competition from American aircraft. Nevertheless, the period during which B.O.A.C. could have expected to gain valuable revenues as the pioneer large-scale operator of long-range jet airliners has been significantly reduced.

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PRE-CAST PRESTRESSED CONCRETE

The practice of pre-casting concrete members, either on the site or in a factory, and then erecting them to form a framed structure is not a new procedure, though it is one which has been developed considerably in post-war years, particularly in conjunction with the use of prestressed concrete. Indeed such members now offer a competitive alternative to steel for the construction of buildings where large clear working floor-spaces are required. Two examples may be quoted where such members have been used: Acton "B" power station, built for the British Electricity Authority by Sir Robert McAlpine and Sons, Limited (reported in ENGINEERING, vol. 175, page 275, 1953) and the two workshops now in the course of being completed for Brooke Marine, Limited, Lowestoft, by the Dowsett group of companies and described on page 154 of this issue. In each case, the buildings are over 300 ft. in length; the power-station turbine house is 64 ft. wide by 60 ft. high and the workshops 75 ft. wide by 41 ft. 6 in. to the roof-beam soffits. In both cases the main columns support rail beams for overhead electric cranes.

In the case of the power station, built during 1951, concrete members were adopted solely as a means of avoiding the use of steel, then in very short supply. The workshops, however, have been built of concrete because, it is claimed, they were cheaper than steel structures, and they are expected to require less maintenance. With modern factory-made concretes having compressive strengths at 28 days of 10,000 lb. per square inch and upwards, and the members being adequately prestressed, there is good reason for believing that such structures will have lives no shorter than the comparable steel buildings.

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PROPOSED ROYAL COLLEGES

The establishment of Royal Chartered Colleges of Technology having the right to award their own degrees of Bachelor of Technology are among the measures advocated by the Parliamentary and Scientific Committee, in a memorandum, "Higher Technological Education," published recently. The colleges, which are intended to supplement the universities, would offer full-time advanced sandwich courses, part-time and evening courses, post-graduate courses, and facilities for research on both a full-time and part-time basis. Entry would be either direct from school or by Ordinary National Certificate, but the colleges would require high qualifications for entry as it is deemed by the committee to be important that the award made by the colleges should qualify the students for post-graduate work in a Royal College or university.

The committee recognise, however, that the standard to be reached at the colleges is very dependent on an improvement in the quality of intake from the schools, and a request is made to the Ministers concerned that the Government will take early appropriate action. The committee feel that there is still scope for greater co-operation between industry, the universities and the technical colleges. The universities are recommended to undertake more sponsored research, and, in the view of the committee, it should also be possible for greater use to be made of teaching staffs in industry and of industrialists as part-time or temporary whole-time teachers in both the universities and technical colleges. The report can be obtained on application to the secretary, Parliamentary and Scientific Committee, 31 Palace-street, London, S.W.1, price 2*s*.

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A "POWER-STATION" LOCOMOTIVE

Alone among American railways the Norfolk and Western are still developing the steam locomotive. Mr. C. E. Pond, the General Superintendent of Motive Power, seeks to make effective use of the indigenous coal which is close at hand. The latest addition to his locomotive stock, described in this issue of ENGINEERING, is a non-condensing steam-turbine machine designed to haul heavy freight trains. It is a remarkable engine, though the principal components are based on established practice in other branches of engineering.

The purpose of the design, work on which was started five years ago, is to provide a coal-burning locomotive having the flexibility of electric drive and a thermal efficiency which will result in fuel costs at least as low as those of other forms of motive power. Stationary and yard tests, now to be supplemented by road tests over the railway's mountain division, have indicated that the design requirements may, indeed, be met. It was a wise decision to use bogies which have been proved in Diesel-electric service, for apart from the advantage of standardisation one "unknown" in a novel design of locomotive is thus eliminated. If too many changes in component design are incorporated in a locomotive it can be difficult to assess the efficiencies and isolate the failures of individual components. Double the efficiency of the average coal-burning reciprocating steam locomotive is expected from the new engine. The exact figure has not been stated, but it may not be as high as British locomotive practice might suggest, because the Norfolk and Western has some very mountainous routes, where partially-burnt cinders are regularly discharged from locomotive chimneys, and because mechanical stokers are not particularly efficient in comparison with hand firing, though they are essential in the United States to suit the high firing rates. The new design is as near as the steam locomotive is ever likely to reach to the ideal of power-station efficiency.

BRITAIN'S GREATEST MARKET FOR ENGINEERING

1.—AUSTRALIA'S GROWTH AND NEEDS

The purpose of this article is to assess the importance of Australia to British engineering and to show what, in the economy of that country, influences demand for British engineering goods. British executives in engineering companies, particularly the technical salesmen, but also others in contracts, estimating and design departments, may find in an article of this type a great deal to explain why their products do well or badly in the market in question. Many of the influences at work will be outside their control, but some will not; in any case market consciousness and understanding on their part can but further the interests of British engineering in the struggle already begun against foreign competitors, most of them from Germany, the United States and Japan and against some local industries protected, in Australia, by high tariffs.

The article is in two parts; the first analyses the source and nature of Australian needs for engineering products, and discusses trends of capital investment in Australia. The second, to be published next week, will describe and analyse the growth of primary industry, such as agriculture, wool, coal and the newly-found oil, developments in the provision of services – "tertiary industry" – such as transport, irrigation and electricity, and the growth of secondary (i.e., manufacturing) industry which includes a large and rapidly developing engineering industry.

An attempt is made throughout to relate such developments in Australia to the demand for British engineering products. This should enable the export technical sales executive to assess the trend of demand for his own particular products. It is the lack of this type of information, written from the engineering standpoint, which promoted this article.

PRE-WAR AND POST-WAR

Australia before the war was the leading British market, taking about 8 per cent. of total exports from the United Kingdom, roughly equal to the value of exports to the Union of South Africa or to the British Colonies. She was the third most important source of imports into the United Kingdom, after the United States and Canada, accounting for 7·8 per cent. of the total. In 1951, before the Australian Government imposed restrictions on imports, 12½ per cent. of United Kingdom exports went to Australia, a proportion greater than that to all United Kingdom colonies and nearly twice that to the next largest market for U.K. goods, the Union of South Africa. Import restrictions led to a fall in total U.K. exports of nearly one-third from the 1951 peak to the £221 millions of 1952, and to a further fall of 4 per cent. in 1953. Relaxation of controls in 1954 was followed by a good recovery, although in the first four months the level was still about 19 per cent. lower than during 1951.

The significance of these figures is that they suggest that the post-war importance of the Australian market to United Kingdom exporters was the result, at least in part, of inflationary conditions in Australia. In the peak year, 1951, the value of U.K. exports to Australia was 8·4 times greater than in 1938, compared with increases for other large markets ranging from 5·8 times (New Zealand) to 4·2 times (Union of South Africa). Exports to Canada, whose capital investment since the war in primary and tertiary industry has been at a substantially higher rate than that of Australia, were 5·7 times greater than in 1938. Only exports to U.K. colonies registered an increase comparable with that of exports to Australia. During the first four months of 1954, Australia accounted for 9·7 per cent. of total British exports, and 11 per cent. of total exports of British metal and engineering products. This is considerable, and the embarrassment caused by the sudden restriction of imports to large numbers of British engineering companies, particularly those making motor-cars and durable consumer goods (and a subsequent similar occurrence in India), are sufficient evidence of the risks and difficulties inherent in such a position. An examination of the salient features and trends of the Australian economy will show that the likelihood of another round of import restrictions cannot be dismissed lightly.

TABLE I.—*Australia: Imports by Main Classes of Products, 1953 and 1954.* (£A *thousands*)
10 *Months ending April*

—	1953	Per cent.	1954	Per cent.
Total	426,868	100	544,191	100
Of which:				
Metals and metal manufactures	95,014	22	96,256	18
Electrical machinery and household appliances	22,582	5	20,684	4
Machines and machinery	75,582	18	81,409	15
Vehicles, including aircraft, motor cycles and cycles	43,724	10	55,233	10
Oils, fats and waxes	63,140	15	68,309	13
Textiles	36,593	8	90,464	17

TABLE II.—*Australia: Imports by Main Countries of Origin, 1953 and 1954* (£A *thousands*)
10 *Months ending April*

—	1953	Per cent.	1954	Per cent.
Total	426,868	100	544,191	100
Of which:				
United Kingdom	175,655	41	263,227	48
Canada	16,969	4	14,773	3
Ceylon	7,527	2	11,199	2
Indonesia	18,515	4	17,609	3
Germany	11,157	3	16,410	3
U.S.A.	75,504	18	58,825	11

TABLE III.—*Australia: Imports of Metal Manufactures and Engineering Products, 1953 and 1954* (£A *thousands*)
10 *Months ending April*

—	1953	1954
Aluminium	1,985	
Iron and steel and manufactures	25,189	14,
Meters and parts	1,584	2,3
Wires and wire manufactures	2,900	2,700
Electrical machinery and apparatus:		
Cable and wire	3,091	1,597
Radio and television receivers	2,492	1,961
Dynamos and other rotating machines	5,548	5,573
Control apparatus	4,354	3,490
Transformers and rectifiers	3,538	3,281
Agricultural machinery	3,275	3,892
Cranes and other lifting apparatus	1,106	1,301
Hand tools	738	1,284
Machine tools	7,714	6,559
Household appliances:		
Vacuum cleaners	46	300
Washing machines	176	783
Other	139	518
Mining machinery	6,140	3,945
Tractors and parts	9,771	15,309
Other tractive machinery (including locomotives)	18,414	18,778
Office machinery	2,831	3,569
Printing machinery	1,163	1,385
Ball and roller bearings	2,454	2,006
Sewing machines	1,381	2,247
Textile machinery	2,210	3,119
Vehicles:		
Motor vehicles: Chassis and parts	21,043	33,359
Bodies and parts	2,751	6,593
Aircraft and parts	10,910	4,745
Motor cycles	408	1,105
Cycles	146	478
Other and parts	8,486	8,953
Total	151,983	155,291

PATTERN OF AUSTRALIAN TRADE

In the ten months ended April, 1954, Australian imports totalled £A544 millions, compared with £A427 millions in the corresponding period of 1953 – an increase of 27 per cent. These are shown in Table I by main categories, and in Table II by principal countries of origin. Metals and engineering products accounted for 47 per cent. of the total in 1954, compared with 55 per cent. in 1953, and were obtained almost entirely from the United Kingdom and the United States. Details of these imports are given in Table III. The striking feature of these statistics is the high proportion of the total which consists of consumer goods and machinery suitable for the equipment of secondary industry. The proportion accounted for by heavy engineering products, agricultural machinery, heavy vehicles, pumps and irrigation plant, is lower than would be expected from a country which derives most of its wealth from the production and export of primary products. The official bias in favour of the secondary industries – whose political influence is greater than that of any other industrial group – was strengthened during 1952, when the virtual cessation of imports provided a shield behind which a substantial expansion of secondary industries took place, some of it quite uneconomic.

Australian exports during 1953 and 1954 consisted mainly of wool and hides, meat and agricultural products. In 1953, wool accounted for nearly half the total and in 1954 for over 53 per cent. Exports of agricultural products, mainly wheat, flour and barley, fell by 6 per cent., and exports of meat by 12 per cent. during the same period. Other exports of importance were metals and machinery, which amounted to £A56 millions in 1954 and accounted for about 7½ per cent. of the total, followed by minerals (6½ per cent.) and gold and silver (1·8 per cent.). The recent fall in world wheat price levels is serious for Australia, particularly as the wheat is soft wheat which does not keep well, and as the country is short of storage space.

The destinations of Australia's exports show that Japan was the third largest buyer of Australian products, after the United Kingdom and France. In all, Australia sold £A84 millions worth of goods to Japan in 1952-53 and took only £A4·7 millions worth in return. The federal Government is well aware of the value of Japanese support at wool sales—particularly since the Soviet Government's announcement that it is no longer a buyer following the severing of diplomatic relations over the Petrov case—and the rigid restrictions against the entry of Japanese goods are being relaxed, despite local manufacturers' opposition. The latest half-yearly survey by the Department of National Development, published last month, drew the following comment from *The Times* (June 30, 1954): "The impression left by the Survey, rightly or wrongly, is that Australia is once more drawing near to the point where any relapse in export earnings might have critical reactions on internal activities. Happily, prices of wool, which accounts by value for nearly half of Australia's exports, remain relatively strong, though on the other side of the ledger, wheat and flour shipments have been running latterly at only half last year's rate. Generally, export earnings, it would seem, are now even more narrowly based than in 1950-52."

The country's trading surplus with the rest of the world fell from £A294 millions at the end of 1951-52 to £A170 millions at the end of 1952-53. Overall the trade situation requires careful watching, as any weakening in the

price of wool must mean drastic cuts in imports which are likely to be even more swingeing than those which enabled Australia to ride the 1952 crisis.

THE SPREAD OF INDUSTRY

In 1952, the last year for which detailed statistics are available, the working population numbered about 3½ millions, of which 28 per cent. – by far the largest group – were employed in manufacturing industry, and 15 per cent. in retail and wholesale trade. Primary industry accounted for 12½ per cent. and transport for 9 per cent. The manufacturing labour force declined from 912,300 in November, 1951 – the post-war peak – to 837,300 a year later but had risen to 864,500 last April. These figures will be discussed in the second part of this article, which contains detailed information on the structure and capacity of Australian manufacturing industries. The purpose of such figures in this context is to show the relatively low employment in primary industry. Mr. Gilbert Burck, writing in *Fortune* (September, 1950) after a visit to Australia, commented as follows on the country's potential : " (Australia) . . . almost exactly as large as the United States if much less abundantly endowed with natural resources, can feed two or three times its eight million inhabitants without changing its present mode of agriculture, can feed many millions more by diversified farming, and can employ an almost indefinite number in industry."

It would now seem that Australia's natural resources are likely to prove of considerably greater importance than was formerly supposed. The discovery of oil at Exmouth Gulf and subsequent tests suggest that the desposit is substantial, and that strikes are likely in other areas, particularly in Papua and New Guinea. The outlook for uranium production is gradually improving. In addition to the mining operations at Rum Jungle there have been promising finds at Radium Hill, Myponga, Lake Dundas, Mount Isa and Adelaide River near Darwin.

TABLE IV.—*Australia: Public Authority Expenditure on New Works and Maintenance** (£A millions)

—	1948-49	1949-50	1950-51	1951-52	1952-53†
Post Office	12	15	22	28	28
Railways	31	19	31	45	40
Roads	31	37	46	56	60
Other transport	11	15	17	23	24
Electricity and gas	17	31	53	77	88
Coal and Briquettes	4	10	16	18	11
Water supply and sewerage	10	12	18	22	22
Irrigation, forestry, land development, etc.	12	17	21	30	22
Dwelling construction	15	19	24	36	34
Schools, hospitals and other buildings	14	25	33	43	38
All other	15	18	25	32	30
Total	154	218	306	410	397

* Includes capital expenditure but not maintenance expenditure by public authority business undertakings.
† Preliminary estimate.

These developments suggest that over the next decade a substantial expansion will take place in Australian extractive industries.

The major addition to Australia's national product is, however, likely to come from the land. In the past year it has become established beyond doubt that the productivity of the land can be greatly increased, and some major projects are under way to bring into production areas that have hitherto been left waste, such as the 90-mile desert between Adelaide and Melbourne. Despite these developments the expansion of agricultural wool and livestock production is being retarded by an acute shortage of labour, certain materials and equipment and capital. A survey of the agricultural situation over the three years 1950-53 published last May by the National Security Resources Board points out that the rural labour force, 404,000 when the survey was published, is entirely inadequate. There was an increase of 8,000 in 1952-53, but the number is still about 5 per cent. less than in 1938. The Board reported a shortage of certain types of agricultural machinery, particularly heavy ploughs and tillers, harvesters and tractors, some of which will have to be imported. The number of tractors on rural holdings increased by 10 per cent. in 1952-53, and despite the very high cost of the machines needed to make good the acute shortage of labour, the Board conclude that " both in the short and the longer term, there is a better promise of applied science in farming than was apparent just before or just after the war."

CAPITAL INVESTMENT

Australian capital investment statistics are not very satisfactory, since it is not possible to isolate certain items, such as private cars, from the figures given. Table IV shows capital expenditure by Public Authority on new works and maintenance, and Table V shows capital expenditure by " private businesses subject to payroll tax—excluding rural industries." It is clear from these tables that secondary industry and distribution are getting the major share of available capital. The figures shown in Table V do not, however, include investment in rural industries, the purchase of road vehicles or the expenditure on private building, which together amounted to £A481 millions. Road vehicles alone accounted for 35 per cent. of this, housing (less housing authority construction) for 32 per cent. Capital investment for productive purposes in the rural industries cannot therefore have exceeded £A159 millions, and a proportion of this expenditure is likely to have been invested in urban development.

Private investment in industry, shown in Table V, is largely in secondary industry and in wholesale and retail trade. Investment in public utilities, mining and transport accounted for only £A38 millions, less than one quarter of the amount spent on road vehicles. Public expenditure, under the same headings, as shown in Table IV, amounted to £A295 millions, mainly on transport and electricity and gas generation.

TABLE V.—AUSTRALIA: NEW CAPITAL EXPENDITURE ON BUILDINGS AND EQUIPMENT BY PRIVATE BUSINESSES SUBJECT TO PAYROLL TAX (EXCLUDING RURAL INDUSTRIES)* (£A millions)

—	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53
Engineering, vehicles	19·5	24·0	25·3	34·3	43·6	59·9
Textile	2·9	3·2	4·3	4·2	4·4	3·4
Clothing	2·7	3·0	3·1	3·1	3·9	2·1
Food, drink, tobacco	7·9	9·5	12·5	16·6	21·1	28·5
Paper, printing	5·7	7·9	10·9	12·3	16·0	8·7
Gas, electricity	4·2	6·1	5·1	7·5	8·7	14·2
Other manufacturing	11·6	12·0	16·3	23·3	31·1	28·5
Mining	2·8	4·1	5·8	8·5	12·9	13·2
Transport	5·4	7·0	5·9	9·3	10·3	11·0
Wholesale, retail trade	16·1	17·3	18·2	24·1	38·3	42·3
All other	6·6	6·7	9·4	12·6	17·3	13·9
Total	85·4	100·8	116·8	155·8	207·6	215·7

* Excludes private capital expenditure on road vehicles, housing and farming.

Expenditure on water supply and sewerage, irrigation, forestry and land development amounted to only £A22 millions, and has averaged less than £A13 millions over the past six years. Despite considerable opposition from some of the States, the Commonwealth Government recently decided to limit the amount to be raised by public loans needed to finance their works programmes to £A200 millions, against requests for £A380 millions. Mr. Menzies argued that new inflationary trends in the economy imposed the exercise of much restraint in the use of loan money. Major capital schemes will therefore continue to lack adequate finance, and will in consequence be delayed.

Details of the major investment programmes now in progress, such as the Snowy River scheme and the Kiewa hydro-electric undertaking in North-Eastern Victoria, will be discussed in the second part of this article, which will also deal with the growth of manufacturing industry in Australia under a high tariff wall and the implications of this growth for British engineering companies.

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MACHINES DANGEROUS TO YOUNG PEOPLE

New Safety Order

Approval has been given by the Minister of Labour and National Service to a new Order prescribing machines at which young persons must not work, unless they are fully instructed as to the dangers involved and the precautions to be observed, and have either received sufficient training or are under adequate supervision.

The principal effect of the Order, which has been made under section 21 of the Factories Act, 1937, is to extend the list of machines prescribed in a similar Order issued in 1938. Among the apparatus now included are worm-pressure extruding machines, loose-knife punching machines, wire-stitching machines, corner staying machines, semi-automatic wood-turning lathes, carding machines and gill boxes used in the wool-textile industry, and calenders, washing machines and garment presses used in laundries.

In his annual report for the past year the Chief Inspector of Factories again stressed the importance of seeing that young persons under 18 years of age, employed in factories and workshops, should be given adequate instruction on the dangers of the machines they use and the proper precautions to be observed, including the use of the guards and safety devices required to be provided under the Factories Acts.

The Order, which will be known as the *Dangerous Machines (Training of Young Persons) Order, No.* 921, 1954, is obtainable from H.M. Stationery Office, London, price 2*d.* net, and its provisions will come into force on August 1, next.

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IMPULSE TESTS ON 275-kV TRANSFORMERS

Impulse withstand tests have recently been carried out at the Trafford Park works of Metropolitan-Vickers Electrical Company, Limited, on a 120-MVA 132/275-kV three-phase auto-transformer, which is one of eight that are being manufactured for the British super-grid. The complete voltage withstand levels, based on a 1/50 microsecond wave, are 1,050 kV for the 275-kV and 550 kV for the 132-kV winding. On-load tap changers are provided at the 132-kV terminals to give a voltage variation of ± 15 per cent. in 18 steps and these, with the tappings, are subject to the full impulse voltage.

The sequence of the tests, which were applied to both windings in turn and were successfully withstood, was one calibration shot, one 100 per cent. full-wave shot, two 115 per cent. full-wave shots and two 100 per cent. full-wave shots.

CONTRACTS

Steam Turbo-Alternator Set. The Nova Scotia Light and Power Co. have placed an order with the ENGLISH ELECTRIC CO. LTD., Marconi House, Strand, London, W.C.2, for a 45,000-kW 3,600 r.p.m. steam turbo-alternator set, complete with feed-heating and condensing plant, for installation at their Water Street Power Station in Halifax, Nova Scotia. The turbine is designed to operate with steam at a pressure of 900 lb. per square inch gauge and a temperature of 900 deg. F., at the turbine stop valve. The alternator is of the hydrogen-cooled type for generation at 13,200 volts, three-phase, 60 cycles.

Complete Power Station. THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have undertaken, as a comprehensive contract valued at over £2 million, the complete power station for the £20 million iron and steel project of Colvilles Ltd., at Motherwell, briefly described in a "Weekly Survey" note on page 66 of our issue of July 16. The contract includes the power-house building and associated civil work; four BABCOCK AND WILCOX gas and oil-fired boilers, each of 125,000 lb. per hour capacity; three 10 MW turbo-alternators with MIRRLEES WATSON condensing and feed-water heating plant, feed pumps and auxiliaries; and two steam turbo-driven centrifugal blowers of 11,000 h.p. each, for supplying air to the furnaces. The work also includes two reinforced-concrete natural-draught towers, each for cooling 1,200,000 gallons of water per hour; two pumps, driven by turbines arranged to exhaust steam to the process plant: and 11-kV switchgear.

Railway Traffic Control Apparatus. THE WESTINGHOUSE BRAKE AND SIGNAL CO., LTD., 82 York-way, King's Cross, London, N.1, have been awarded two contracts for the supply of centralised traffic-control apparatus in Rhodesia and New Zealand. The first installation will cover 85 miles of single railway track having 15 fully-signalled crossing stations and will be controlled from a station at Sawmills, about 60 miles from Bulawayo. Equipment of a similar type is being supplied to the New Zealand Railways for the Upper Hutt-Featherstown section of line ten miles in length and having three crossing stations.

Diesel Engine for Tractors. An order has been placed by Industrija Motora, Rakovica, Belgrade, Yugoslavia, for 2,000 Diesel engines which are to be built at the Peterborough Factory of F. PERKINS LTD. The order approaches £500,000 in value. The engines, which are of the P4 (TA) type rated to give 42 b.h.p., at 2,000 r.p.m., will be fitted into the Yugoslav Zadrugar agricultural tractors designed and manufactured by Industrija Motora.

Ladle Cranes. The ADAMSON-ALLIANCE CO. LTD., 165 Fenchurch-street, London, E.C.3, have received an order from the Australian Iron and Steel Co. Ltd., Broken Hill, Australia, for one 400-ton and one 170-ton ladle cranes, and one 200-ton stripper crane.

Mobile Ground Power Units for Aerodromes. Two British firms, AUTO DIESELS LTD., Uxbridge, and CROMPTON PARKINSON LTD. have secured a substantial order from the United States Government for the delivery of mobile ground power units for the starting of jet aircraft. The value of the equipment, which is for the use of the Allied Powers, is over 1,500,000 dols.

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SIR ERNEST W. PETTER: ERRATUM

We regret that in our obituary notice of Sir Ernest W. Petter (ENGINEERING, July 23, page 100) we stated that "the oil-engine business also changed hands, being taken over by the Vickers interests, who transferred the manufacture of the larger engines to Ipswich." Petters Limited have pointed out that the only association they had with Vickers Limited was in the formation, in 1919, of a private company, Vickers Petters Limited, to make their large engines at Ipswich. In 1927, Petters Limited bought out the Vickers interest, and in 1928 closed down the Ipswich works and transferred the heavy engines back to Yeovil. The "Petometer" calculating machine, to which we referred, was the work of the late Mr. G. B. Petter, not Mr. P. W. Petter as stated. It was eventually sold to the Bell Punch Company, Limited, who manufactured it as the Sumlock machine.

Obituary

SIR HERBERT G. WILLIAMS, BART., M.P.

We regret to record the death of Sir Herbert Williams, which occurred in London on Sunday, July 25. He was sixty-nine years of age. Although trained as an engineer, he was better known for his Parliamentary activities and as an outspoken critic of all parties in the House of Commons.

Herbert Geraint Williams was born at Hooton, Cheshire, on December 12, 1884, and was educated at the local grammar school and at Liverpool University. He entered the university as a Rathbone scholar and graduated in engineering with first-class honours in 1906. A year later he obtained second-class honours and became a university scholar and medallist in mathematics. He obtained the degrees of Master of Science in 1908 and Master of Engineering in 1910.

He served an apprenticeship with Siemens Brothers Dynamo Works at Stafford and subsequently assisted Mr. L. A. Smart and Sir John Norton Griffiths in their consulting practice, being engaged under the latter in work connected with the construction of a low-level sewer between Battersea and Deptford. In 1911 he was appointed secretary of the Machine Tools Trades Association, a position he occupied until 1928, although during the war he was secretary of the Machine Tool Department in the Ministry of Munitions and a lieutenant in the Royal Army Ordnance Corps. From 1920-22 he also acted as joint secretary of the Engineering and Shipbuilding Hours of Labour Investigation Committee and was subsequently Executive Director of the Incorporated Association of Electric Power Companies.

His political career began in 1924 when, after several failures, he was returned to Parliament as the Conservative member for Reading, being appointed Parliamentary Secretary to the Board of Trade four years later. He was, however, defeated in the 1929 election and did not enter Parliament again until 1932, when he was returned for South Croydon. He was again unsuccessful in the election of 1945, but was re-elected for East Croydon in 1950, a seat he was still holding at the time of his death. During the 1939-45 war he was frequently outspoken in his criticisms of the Government.

Williams received a knighthood in 1939 and was created a baronet in 1953. He was elected an Associate Member of the Institution of Civil Engineers in 1910. He served on the board of a number of companies including Bennis Combustion, Limited, Franco Signs, Limited, and the Power Plant Company, Limited; and was president of the Ballast Sand and Allied Traders' Association and of the Engineers' Buyers and Representatives Association. He was an active propagandist for his party and was the author of several books on economic and political subjects.

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MR. J. L. ADAM, C.B.E.

Ship Design and Survey

It is with much regret, which will be shared by very many naval architects, shipowners and shipbuilders, that we record the death on July 22, at his home on Seil Island, near Oban, of Mr. J. L. Adam, C.B.E., the last Chief Surveyor of the British Corporation Register of Shipping and Aircraft. Mr. Adam, who was in his 71st year, retired in 1949, when the British Corporation Register amalgamated with Lloyd's Register of Shipping.

John Lochnead Adam received his early training in naval architecture in the ship drawing office of D. and W. Henderson and Company, Limited, at Partick, Glasgow, where he served his apprenticeship from 1899 to 1905, concurrently attending the evening classes at the Glasgow and West of Scotland Technical College. He then went to Leith as a ship draughtsman in the yard of John Cran and Company, who were chiefly noted as builders of ocean-going tugs but who also constructed a variety of coasters and small cargo ships. Before long he was made chief draughtsman, though still only in his early twenties. In 1910 he left Leith for Southampton, where he spent the next two years as a senior draughtsman in the Woolston shipyard of John I. Thornycroft and Company, leaving them early in 1912 on appointment as surveyor to the British Corporation.

On the outbreak of war in 1914, Adam joined the Army, but the need for a rapid expansion of shipbuilding output led to his release after a year's service. From January, 1918, he was the principal surveyor in charge of the British Corporation's head office in Glasgow and in 1927 he was promoted to the position of Assistant Chief Surveyor, under the late Dr. J. Foster King. In 1940, when Dr. King retired after more than 50 years with the British Corporation, 36 of them as Chief Surveyor, Mr. Adam succeeded him, retaining the office, as stated above, until the Corporation was amalgamated with Lloyd's Register.

Mr. Adam was a prominent and active member of the Institution of Naval Architects, being elected to the Council in 1930 and made a Vice-President in 1942. Ten years later he was elected an Honorary Vice-President, as Dr. J. Foster King had been before him, in recognition of his contributions to naval architecture, especially in connection with the development of welded ships. He was closely associated, during the second World War, with naval and mercantile developments in this direction, and for this work he was appointed C.B.E. He was a member of the Admiralty Ship Welding Committee, President of the Institute of Welding in 1947-48, and a founder member of the International Institute of Welding. He was also a member of the Institution of Engineers and Shipbuilders in Scotland, and an Honorary Fellow of the North-East Coast Institution of Engineers and Shipbuilders. For a number of years, from 1943 onwards, he was a member of the Engineering Divisional Council of the British Standards Institution. His numerous papers before the leading institutions concerned with naval architecture were notable for their thoroughly practical character, and he was one of the comparatively few recipients of the Gold Medal of the Institution of Engineers and Shipbuilders in Scotland, which was awarded to him in 1933 for a paper on "Electric Arc Welding in Ship Construction." He was also a keen yachtsman, and not only designed, but himself built his own yacht.

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We regret also to record the deaths of the following:

MR. ALBERT EDWARD ERICKSON, at his home in Broad Green, Liverpool, on July 8 after a brief illness at the age of 56. He was mining superintendent of the home sales department of the Automatic Telephone and Electric Co. Ltd., Strowger Works, Liverpool, 7, having joined the company in 1919 as a draughtsman-designer. He was a Fellow of the Association of Mining Electrical and Mechanical Engineers.

MR. JOHN WILLIAM BAILLIE, at his home at Sutton Coldfield, Warwickshire, on July 14. Mr. Baillie retired in December, 1953, from his position as managing director of Horseley Bridge and Thomas Piggott Ltd., Horseley Works, Tipton, Staffordshire, but continued to sit on the board as consultant director. He joined the staff of the company in 1919 and was elected to the board in 1927. He was made joint managing director with Mr. Arthur Dyson in 1931 and continued as sole managing director when Mr. Dyson retired in 1948. Mr. Baillie was for some years President of the British Constructional Steelwork Association.

MR. WILLIAM GEORGE RIDDELL, O.B.E., in Durban, South Africa, on July 22, at the age of 83. Mr. Riddell, who retired from the positions of chairman and managing director of John Hastie & Co., Ltd., marine engineers, Greenock, in 1934, had joined the firm in 1903. He served his apprenticeship with the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow, and afterwards went to sea, obtaining his chief engineer's certificate in 1896.

PERSONAL

At the recent annual general meeting of the British Internal Combustion Engine Research Association, 111-112 Buckingham-avenue, Slough, Buckinghamshire, VISCOUNT FALMOUTH, M.I.Mech.E., was re-elected President, SIR HAROLD ROXBEE COX, Ph.D. D.I.C., B.Sc., M.I.Mech.E., F.R.Ae.S., DR. S. F. DOREY, C.B.E., M.I.C.E., M.I.Mech.E., F.R.S., chief engineer surveyor, Lloyd's Register of Shipping; MAJ.-GENERAL H. R. B. FOOTE, V.C., C.B., D.S.O., director-general, Fighting-Vehicles Division, Ministry of Supply; and VICE-ADMIRAL (E) F. T. MASON, C.B., Engineer-in-Chief of the Fleet, were re-elected vice-presidents. MR. G. W. BONE, MR. J. CALDERWOOD, DR. A. R. MORCOM and MR. A. V. WILKIN were elected to the Council, which also includes MR. H. D. CARTER, MR. C. G. TANGYE and MR. G. A. MCMILLAN.

MR. W. G. CARTER, C.B.E., F.R.Ae.S., has retired from his post of technical director to the Gloster Aircraft Co., Ltd., Hucclecote, Gloucestershire. MR. R. W. WALKER, chief designer since 1948, has taken his place on the board.

AIR VICE-MARSHAL A. L. JAMES, C.B.E., B.Sc., D.I.C., F.R.Ae.S., M.E.I.C., is to join the board of the Bristol Aeroplane Co. of Canada Ltd., and of its subsidiary company, Bristol Aero Engines Ltd., on September 1, and will be appointed vice-president (engineering) of the latter company.

The honorary degree of D.Sc. has been conferred upon REAR ADMIRAL M. S. SLATTERY, C.B., F.R.Ae.S., chairman and managing director of Short Bros. and Harland Ltd., by Queen's University, Belfast.

MR. WILLIAM CASSON, M.I.E.E., system design and development engineer on the transmission-design branch of the British Electricity Authority, has been appointed transmission-design engineer of the Authority. He succeeds Mr. F. J. LANE, O.B.E., M.Sc., M.I.E.E., who was recently appointed deputy chief engineer (transmission) of the Authority.

MR. F. A. HURST, chairman, and MR. C. F. HURST and MR. F. A. MARTIN, directors of Samuel Osborn & Co. Ltd., Clyde Steel Works, Sheffield, have joined the board of Low Moor Alloy Steelworks Ltd., Bradford. Mr. C. F. Hurst and Mr. Martin will act as joint managing directors of the Bradford firm, control of which was recently acquired by Messrs. Osborn.

MR. J. B. TAYLOR, T.D., manager of the Leicester branch of the General Electric Co. Ltd., has been made managing director of the British General Electric Co. (Canadian) Ltd., in succession to MR. J. S. LANGLANDS, who is to be district assistant manager of the General Electric Co. in Scotland. MR. K. L. V. NICHOLS, of the Ipswich branch, is to be manager of the firm's Leicester branch.

MR. S. ROBERTS has been appointed deputy managing director and general sales manager of Hoover Ltd., Hoover House, 211-213 Regent-street, London, W.1, following the retirement of MR. F. H. BUNN after 33 years of service.

MR. R. H. BINGHAM has relinquished his position on the board of Huntington, Heberlein & Co. Ltd., with effect from June 30, after 44 years of service with the company. MR. S. ROBSON and MR. R. B. SHARP have joined the board with effect from July 1.

MR. F. G. COOK has been appointed commercial manager, Marconi Instruments Ltd., St. Albans, Hertfordshire.

MR. L. C. JARMAN, A.M.I.E.E., A.M.I.Prod.E., has joined Metal Industries Ltd., Victoria Station House, 191 Victoria-street, London, S.W.1, as group personnel officer.

MR. H. G. BOULLEN, B.Sc. (Tech.), A.M.I.E.E., the Lancashire Dynamo Group branch manager for the Nottingham area, has been appointed home sales manager of Lancashire Dynamo and Crypto Ltd. He will take up his new position on September 1 and will operate from the London office of the company at St. Stephen's House, Victoria-embankment, London, S.W.1.

MR. F. HOBDAY has been appointed works manager to Semtex Ltd., Fort Dunlop, Birmingham, in succession to MR. WALTER SAUL, who was recently appointed technical manager to the firm.

MR. R. M. TYRRELL has been placed in charge of the London office of B. and S. Massey Ltd., Openshaw, Manchester, 11, at 131 Victoria-street, S.W.1. This is in consequence of the retirement, owing to ill health, of MR. G. M. TURNBULL, who will continue, however, to represent the firm in the south-western counties.

MR. A. F. LAWRY, A.C.I.S., has joined the Wallace Attwood Company, management consultants, Chantrey House, Eccleston street, London, S.W.1, as a consultant.

MR. R. LANGMEAD, until recently the senior liaison representative of the de Havilland Enterprise in France, has been appointed technical services manager to Smiths Aircraft Instruments Ltd., and its aviation associates.

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BUSINESS CHANGES

SUNROD LTD. inform us that they have now started production at their new factory at Cray-avenue, St. Mary Cray, Kent. Inquiries for all forms of heat exchangers, however, will continue to be dealt with at their London office, 1 and 2 Hen and Chickens-court, 184 Fleet-street, E.C.4.

LLOYD AND ROSS, LTD., 58 Victoria-street, London, S.W.1, representatives in the United Kingdom for MASCHINENFABRIK ESSLINGEN, Germany, have arranged to import that company's Emperor fork-lift and Ram trucks of 10 tons and 15 tons lifting capacities. At the same time, Lloyd and Ross, Ltd., have appointed MATERIALS HANDLING EQUIPMENT (GREAT BRITAIN) LTD., 7 Chesterfield-gardens, Curzon-street, Mayfair, London, W.1, to be their main distributors.

GEORGE KENT LTD., Luton, Bedfordshire, and FOXBORO-YOXALL LTD., London, S.W.19, have made arrangements for the mutual marketing of the Foxboro d/p (differential-pressure) cell and the Kent oxygen analyser in the United Kingdom.

VOKES LTD., Henley Park, Guildford, Surrey, have removed their London office to 123 Victoria-street, S.W.1. (Telephone: VICtoria 4550.)

THE NON-FERROUS DIE CASTING CO., LTD., Nonferdica Works, North Circular-road, Cricklewood, London, N.W.2, have formed an associate company, BRASS PRESSINGS (LONDON) LTD., for the production of hot stampings and pressings in brass, bronze and aluminium.

THE JOHN THOMPSON GROUP OF COMPANIES have opened a new branch office in the North of England, at Ravenswood, Westfield-lane, Ryton-on-Tyne, Co. Durham.

THE INTERNATIONAL MEEHANITE METAL CO. LTD. are moving to new office premises at Meerion House, 4 Downside, Epsom, Surrey, as from August 1. (Telephone: Epsom 3507/8.)

AIR CONTROL INSTALLATIONS LTD., Ruislip, Middlesex, are opening a branch office in the Newcastle-upon-Tyne area, at 76 Holywell avenue, Whitley-Bay, Northumberland. (Telephone: Whitley Bay 23046.) The branch manager is MR. N. J. SHERGOLD.

CROFTS ENGINEERS (HOLDINGS) LTD. have acquired the whole of the share capital of J. PARKINSON & SON (SHIPLEY) LTD., machine-tool and vice makers, Shipley, Yorkshire. Messrs. Parkinson will continue to operate as before with the same staff and management, under the direction of MR. EDWARD and MR. HARRY PARKINSON as joint managing directors.

The amalgamation of the LINDE CANADIAN REFRIGERATION CO. LTD., Montreal, Quebec, with J. & E. HALL LTD., Dartford, Kent, has been completed. The new organisation operates under the title, LINDE HALL CANADIAN REFRIGERATION DIVISION of J. & E. HALL LTD., and is under the managership of MR. J. H. C. MCGARRY. The assistant manager is MR. J. C. E. LOWCOCK. The head office of the Linde-Hall Division will be at 5031 Cote de Liesse Road, Montreal. The head office of Messrs. Hall's Canadian escalator and elevator branch will be at 267 Davenport Road, Toronto, Ontario.

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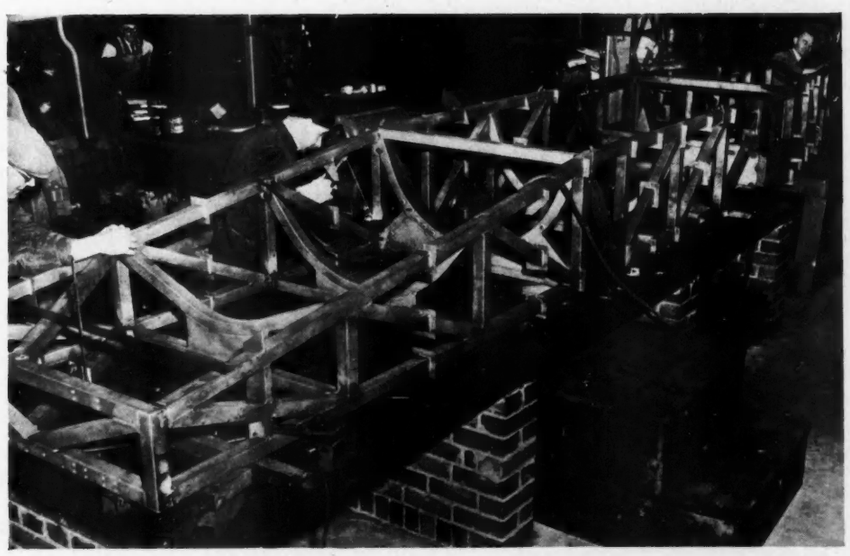
TUBULAR FRAMEWORK FOR RACING MOTOR BOAT

An Attempt to Regain the World's Water-Speed Record

Accles and Pollock Limited, Oldbury, Worcestershire, have completed a tubular steel frame for a motor boat in which Mr. Donald Campbell will attempt to regain the world's water-speed record, at present held by the United States. The frame, which has been built to a design and specification prepared by Mr. Campbell and his consulting engineers, is of chromium-molybdenum seamless tube, to British Standard T.60. The tube is mostly of 2 in. square section, and 14 and 16 s.w.g. wall thickness. About 275 ft. of tube have been used in the frame, which is 24 ft. long, 3 ft. 8 in. wide, and 2 ft. deep. There are about 250 welded joints, and the total welding run is about 200 ft. The welding was carried out with the tubes in the heat-treated condition, a special welding sequence being devised by Accles and Pollock to prevent distortion. The specification calls for a minimum ultimate tensile strength after welding of 50 tons per square inch. All the welds were tested with a magnetic crack detector.

The frame has been designed to be as light as possible consistent with the necessary strength, and weighs only 580 lb. Mr. Campbell pointed out, in a recent interview at the works of Accles and Pollock Limited, that the stresses imposed by very high speeds on water are not fully known, but the present frame has been stressed in the vertical plane to a factor of 27g.

The boat will be powered by a Metropolitan-Vickers straight turbo-jet engine giving a static thrust of 4,000 lb., and it will be used to obtain scientific data as well as to make the attempt on the speed record. It will be fitted with various electronic devices, details of which are not yet available, to provide a continuous indication and record of stresses while it is travelling.



All-welded high-tensile tubular frame for the racing motor boat in which Mr. Donald Campbell hopes to regain the water-speed record for Great Britain.

THE WORLD'S SHIPBUILDING

The steamers and motorships under construction in the shipyards of Great Britain and Northern Ireland on June 30 totalled 328, making together 2,195,085 gross tons and representing an increase of 19,325 tons over the figure for March 31 last. Of the total, 89 vessels comprising 573,834 tons were being fitted out afloat and 239, aggregating 1,621,251 tons, were still to be launched. The "Shipbuilding Returns" of Lloyd's Register of Shipping, 71 Fenchurch-street, London, E.C.3, for the three months ended June 30 indicate that there was an even flow of tonnage from the "commenced" to the "completed" stage during the quarter. Thus, 66 ships making together 356,442 tons were commenced; 63 ships, comprising 350,340 tons were launched; and 60 vessels totalling 345,872 tons were completed. The oil tankers under construction total 89, aggregating 1,135,693 tons, which is an increase of 18,695 tons over the figure for the last quarter and represents 51·7 per cent. of the total tonnage under construction in this country.

THE POSITION ABROAD

In shipyards overseas, the steamers and motorships under construction on June 30 totalled 764, comprising 3,653,806 gross tons, a decline of 337,436 tons as compared with the total for March 31. This considerable decrease in tonnage building occurred mainly in the United States, Japan and Italy. As has been the case for many years now, figures are not available for China, Poland and Russia. Germany heads the list of overseas shipbuilding countries, her total for June 30 being 679,848 tons. Second come the Netherlands with 443,705 tons; then follow Sweden with 430,757 tons, France with 411,514 tons, the United States with 340,007 tons, Japan with 256,816 tons and Italy with 223,143 tons; all other countries had totals of less than 200,000 tons. The progress made abroad during the quarter is shown by the fact that 204 ships comprising 723,881 tons were commenced, 259 vessels aggregating 1,210,245 tons were launched and 251 ships making together 1,066,641 tons were completed. Work has been suspended, however, on 11 ships totalling 19,792 tons. Oil tankers being built abroad totalled 195, making together 2,217,829 tons. This, although 107,814 tons below the figure for March 31, nevertheless represents 60·7 per cent. of the total tonnage being built abroad.

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THE INSTITUTION OF ELECTRICAL ENGINEERS

Elections to Council

The result of the ballot held to fill the vacancies which will occur on the Council of the Institution of Electrical Engineers on September 30 has now been announced. The new President is to be Mr. J. Eccles, C.B.E., and the two vacancies among the vice-presidents will be filled by Dr. Willis Jackson, F.R.S., and Sir Gordon Radley, C.B.E., Ph.D. Mr. H. W. Grimmitt has been elected honorary treasurer and the five new members of the Council are Mr. A. R. Cooper, Mr. F. J. Lane, O.B.E., Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., Mr. W. F. Parker and Mr. E. L. E. Wheatcroft. The vacancy on the Council among associate members is to be filled by Dr. J. H. Westcott and that among associates by Mr. J. Bennett. The Council have coopted Mr. B. Donkin to fill the casual vacancy created by the election of Dr. Willis Jackson, F.R.S., as a vice-president before the completion of his term of office as an ordinary member of Council.

BOOK REVIEWS

Applied Heat and Heat Engines. By LESLIE PILBOROUGH. *Butterworths Scientific Publications*, 88, *Kingsway, London, W.C.*2. (35*s.*)

There are now so many textbooks on engineering thermodynamics that it is difficult for a newcomer to justify its existence. The present work is of an elementary nature, designed to meet the needs of students or apprentices hoping to pass their examinations for the Ordinary National Certificate in the subjects of its title. In eighteen chapters with an average of about eighteen pages apiece, the author traverses a field ranging from thermometry to engine-testing, and including the structure and properties of matter; the kinetic theory of gases; heat transmission; fuels and combustion; the properties of steam; boilers and reciprocating engines; internal-combustion engines; steam and gas turbines; and the elementary theory and calculations applying to the respective subjects.

The extent of the ground covered precludes, in general, more than a very superficial treatment. Thus, gas turbines are dismissed in less than four pages, and reaction steam turbines in less than five. Nozzle design is afforded only 21 lines and two small illustrations. Even so, room is unfortunately found for the extraordinary statements that "The convergent-divergent nozzle is used when the pressure ratio lies between 0·58 and 0·546, It may also be used below this value, but its rate of discharge will be reduced." Another piece of information that will surprise engineers who are conversant with boiler practice is that each of the boilers of a battery has in its outlet pipe a spring-loaded valve that will close automatically "should the pressure in any particular boiler be lower than that of the main." The book is easy to read and adequately furnished with illustrations of a diagrammatic kind, so that it may well serve the purpose of the students for whom it is intended. It contains about 170 examination questions with their numerical answers, at the ends of the various chapters, and many more, fully worked out, are included in the text.

Garcke's Manual. A Statistical Record of the British Electricity and Allied Manufacturing Industries, 1953-54. Compiled under the supervision of FREDERICK C. GARRETT. *Electrical Press, Limited*, 19/20 *Noel-street, London, W.*1. (77*s.* 6*d.*)

This statistical record of the British electricity supply and manufacturing industries has now reached its 51st edition and is so well known as hardly to require notice in ENGINEERING. Its value has, however, increased as the years have elapsed and there are few who will deny its usefulness as a book of reference regarding an important branch of engineering. The progress of electricity supply in Britain between 1948 and 1953 is reviewed and full particulars are given of the Central Electricity Authority, of the divisional organisation and of the generating stations controlled, including operating data. Descriptive particulars are also given regarding the administration and organisation of the Area Boards, electricity tariffs and the Consultative Councils. Similar information about the North of Scotland Hydro-Electric Board and electricity undertakings in Ireland, the Isle of Man and the Channel Islands is included. Lastly, there is much useful data about the manufacturing companies and there is a directory of executive personnel.

Electric Traction Handbook (Control). By R. BROOKS. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (30*s.*)

This book deals specifically with the equipment employed for controlling electric trains, trolley buses and tramcars. Owing to the preponderating use of direct current in British practice the author has, perhaps naturally, devoted the larger amount of his space to the apparatus employed in that system; but a general survey of alternating-current systems, including that utilising 50 cycles, has been included. Representative examples of Diesel-electric and gas-turbine-electric equipments are also briefly treated.

After giving some information as to the extent to which electric traction is now used and the various traffic conditions that have to be met, such basic considerations as tractive effort, the performance of the motor, and the functions of the control system are briefly dealt with. The various direct-current control schemes are then described in detail, separate chapters being devoted to resistors, braking circuits, methods of collecting the current, control circuits both for the main traction and auxiliary equipment and lay-out of the equipment. This treatment occupies some 250 of the 320 pages of the book, single-phase traction, Diesel-electric traction and gas-turbine-electric traction being dismissed in about 50 pages.

Since, of the electrically-worked single-track mileage of the world some 44·5 per cent. is operated on the single-phase system, this shows a certain lack of balance and detracts to some extent from the value of the book. Nevertheless, within these limits the work is well done.

Oil in the Middle East: Its Discovery and Development. By STEPHEN HEMSLEY LONGRIGG. Published for the Royal Institute of International Affairs by *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (25*s.*)

Figures for the world reserves of petroleum, assuming the present rate of production, are necessarily speculative, but a broadly accurate picture of the state of affairs is possibly given by the estimates that the reserves of the United States and Mexico will be exhausted in 15 years; those of Venezuela in 20; those of Persia in 34; those of Kuwait in 122; and those of Iraq in 172. These figures presumably do not allow for the possible discovery of new sources, but a significant pointer suggesting the approaching exhaustion of the United States oilfields is that in 1947 the average annual production of a few dozen wells in Persia was 280,000 tons per well compared with an average of 610 tons per well for half-a-million wells in the United States.

Comparisons of this kind are not necessary to accentuate the importance of the great Middle East oilfields extending from Egypt to Persia and taking in Iraq, Arabia, Turkey and Syria. It is possible that new fields, additional to those now known or being worked, may be discovered, but such discovery would not be necessary to make the Middle East a major source of oil.

The early history of oil winning in the United States reflects little credit on those concerned, and the same thing, with more excuse, may be said about one aspect of a large part of the history of oil production in the countries lying in the neighbourhood of the Persian Gulf. It is a matter for no surprise that the sudden acquisition of undreamed-of wealth should have had undesirable reactions in economically-backward countries, politically unstable and with illiterate and potentially-emotional populations, easily swayed by fanatical or self-seeking agitators. The recent history of Persian oil is too familiar to require more than mention, but it is far from being the only case of delay and frustration imposed by recalcitrant governments. It is only in the last few weeks that the Egyptian Government have agreed to modify restrictive practices which have hampered the activities of the Anglo-Egyptian Oilfields, Limited, and the Socony-Vacuum Oil Company, for more than five years, although no Egyptian capitalist or company has ever assisted in a development of prime importance to the country.

In this authoritative book, Brigadier Longrigg traces the whole tangled history of Middle East oil from Palæozoic times to the latest developments in Bahrain and Kuwait. He points out that the presence of petroleum in the Middle East area has been known throughout all human history. Surface bitumen was employed by all generations of men in Egypt, Iraq and Persia,

distillation provided a usable kerosine, while crude oil was used as a medicine. That surface deposits and leakages were evidence of great underground deposits could not be realised by early man, and he could not have done anything about it even had he realised it. Present-day developments had to wait for present-day scientific and technical knowledge and the winning of Middle East oil might have been postponed for centuries had not Western nations intervened. Brigadier Longrigg's reference to the achievement of the Kuwait Oil Company may serve as an epitome of what has been accomplished. In six years a " remote waterless desert " has been equipped " with all the necessities and many of the luxuries of a civilised modern life " and is producing 3 million tons of oil per month.

It was after the first World War that American interests realised that a British oil industry, on a scale challenging the vast American industry, was becoming established. The result was intervention by United States companies. The resulting commercial rivalry led to some incidents which were far from admirable, but Brigadier Longrigg, an old servant of the Iraq Petroleum Company, takes no side; he deals with these matters impartially. His account of the activities, successes and failures of the many companies concerned is so detailed that patience and application are needed fully to appreciate the contents of his book. At one point he himself writes " the reader runs the risk of weariness at the repeated tale of discoveries, development and rapid increases in output." There is no question, however, about the value of this factual record of one of the major industrial developments of the modern world.

The permanent interest of the book does not lie in accounts of commercial squabbles but in its record of an important chapter in the story of the impact of the West on the East. A growing nationalistic fervour in backward countries is a phenomenon of the times. It may be understandable, but that does not make it wise. Such countries cannot with profit take into their own hands the operation of highly technical industries. The history of oil in the Middle East, as recounted in this admirable work, contains much record of factions and self-destroying opposition and of the enterprise and patience with which it has been met. Fortunately, in some important instances, the value of co-operation with the West has now been realised.

Sponge Iron and Direct-Iron Processes. By EDWARD P. BARRETT. United States Bureau of Mines Bulletin No. 519. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (1 dol.)

Sponge iron and direct iron are both products of a direct reduction process. If the reduction, or removal of combined oxygen, is carried out at a temperature below the fusion point of iron, the result is a metallic product of a porous nature, or sponge iron. If, on the other hand, the reduction takes place at a slightly higher temperature, the particles of metal weld together, or even melt, and form pellets or balls which lack the porosity of sponge iron, and can be described as direct iron. Apart from meteoric iron, the use of which was obviously limited, direct iron was the earliest form in which the metal was used by man, and the direct process continued to be the only method of production for centuries. Given a high-grade ore, pure fuel, and considerable skill on the part of the workman, the direct process could produce very good iron, but it was slow and costly, and the output was extremely small. Except in some of the more primitive parts of the world, where the old charcoal bloomery, or some variant of it, is still in use, and in a few instances where more modern methods are used to produce sponge iron, as in Sweden, the direct reduction process is obsolete.

Nevertheless, even in those industrial countries where iron and steel are produced on a large scale by the indirect process, interest in direct reduction has never lapsed entirely, though the process may not have been used for a considerable time. In some areas the subject is, or will be in the future, of increasing importance. The author of this bulletin cites several instances where the sponge iron process may prove useful. Among these may be mentioned the supplementing of existing production methods; the use of idle plant in other industries to produce iron during war time; the utilisation, on the spot, of small deposits of iron ore, which would not warrant the erection of a blast furnace; and the production of iron in areas lacking suitable coking coal. It is in this last connection that the direct iron process may well come to be of particular interest in this country. Supplies of good coking coal are the least abundant among the coal reserves of Great Britain, and any process which will produce iron without the need for large supplies of metallurgical coke should become of increasing interest in the future. Whether or not the sponge iron process is one which could be of value in this connection is a question of some importance, and one which is dealt with at length in the bulletin.

The author draws attention to the fact that the history of sponge iron is discouraging, and that among the many efforts to develop a satisfactory process there are " some monumental failures on record . . ." The problems of producing sponge iron on a commercial basis are many, and the author says that, under present conditions, no one would propose the adoption of sponge iron to replace present metallurgical processes. Nevertheless, conditions are changing, and sponge iron may become an important product sooner than is generally realised.

The author reviews some of the many processes developed over the past century, starting with the reverberatory furnaces tried in England in the 1930s, and deals in turn with multiple-unit charges in various types of furnace, vertical retort furnaces, rotary-hearth and rotary-kiln furnaces, and shaft-type furnaces. Various types of reducing agent are discussed. From this consideration of processes tried in the past, which includes a note of the disadvantages, the author proceeds to deal with fundamental theory and data relating to reduction of iron oxides, and thence to a description of a series of experiments conducted by the U.S. Bureau of Mines over a long period. The methods tried included reduction by crude oil, and in externally-heated rotating tubes, both of which were abandoned because of operating difficulties. Tests on internally-fired rotary kilns, however, indicated that this method offered the best prospect of success for industrial applications.

The use of the rotary kiln was developed further during the early stages of the war, when a shortage of steel-making scrap seemed imminent, and it was demonstrated that sponge iron of low sulphur content could be produced successfully by this method. As a result of these experiments a considerable amount of data was accumulated, and it became possible to formulate a specification of plant requirements and operational procedure; this information is given in the bulletin. The Bureau of Mines also undertook a study of the Swedish Höganäs process, and used brick kilns for firing a mixture of fine oxide, coke, coal or charcoal in containers. It was shown that sponge iron could be produced advantageously by this method, using magnetite, hematite, limonite or other iron ores, and also mill scale and other oxide materials, in tunnel kilns or intermittent downdraught kilns of the type normally used in brickworks. The review of the experimental work shows that better mechanisation of the process, and the use of metal containers instead of ceramic saggers, would probably reduce operating costs materially, and should be worthy of further study.

The review concludes with an examination of the methods used for sponge iron production in Sweden and other parts of Europe, and with the use of sponge iron in steel manufacture. The use of sponge iron as a chemical reagent, as in copper metallurgy, and the making of iron powder, are also considered. There is an extensive bibliography, of international scope, and an excellent index.

TRADE PUBLICATIONS

Lubricants. A booklet has been published by C. C. Wakefield & Co., Ltd., 46 Grosvenor-street, London, W.1, which describes the research department of the Wakefield-Dick Industrial Lubricants Division at Hayes. This is followed by an equally detailed account of the Stanlow refinery. The booklet is fully illustrated.

Control Switches. A booklet issued by A. Reyrolle & Co. Ltd., Hebburn, Co. Durham, describes a range of control switches fitted with either pistol-grip or T handles. Several variations are available and capacities range up to 15 amperes at 550 volts alternating current.

Liquid Level Control. Londex Ltd., Anerley Works, 207 Anerley-road, London, S.E.20, have issued a leaflet describing their " Lectralevel " floatless level-control system. There is a standard model for filling and emptying control, and a modification which signals three levels. The system can be operated from any electricity supply.

Degreasing Agent. An emulsion-type degreasing agent, Pyroclean No. 101, which is used in aqueous solution and operated at an optimum temperature of 160 deg. F. has been introduced by the Pyrene Co., Ltd., Metal Finishing Division, Great West-road, Brentford, Middlesex. It is intended for use in the cleaning section of fully-automatic metal finishing plants such as " Spra-Bonderising " installations. Full details of this agent are given in a leaflet recently published by the makers.

Conveyor and Elevator Chains. The Renold and Coventry Chain Co., Ltd., Didsbury, Manchester, have issued an illustrated leaflet showing how their conveyor and elevator chains can be applied to various task in industry. The standard range covers breaking loads from 3,000 lb. to 15,000 lb. In addition, a range is available covering loads from 24,000 lb. to 85,000 lb.

Workmen's Shelters. Details of a new shelter made from steel tube with a green wax-proofed heavy-duck covering is given in a leaflet published by Remploy, Limited, 25 Buckingham-gate, London, S.W.1. The covering is of the tie-on type, made in one piece, complete with four doors. Three sizes of this shelter are being made. The largest measures 15 ft. by 7 ft. 6 in. by 6 ft. 6 in.

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BOOKS RECEIVED

General Review of the Manufacturing Industries of Canada, 1950. *Dominion Bureau of Statistics, Department of Trade and Commerce, Ottawa, Canada.* (1·50 dols.)

Relaxation Methods. By D. N. DE G. ALLEN. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.*; and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (53*s.* 6*d.*)

Metals Engineering—Design. A.S.M.E. Handbook. Edited by OSCAR J. HORGER. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (10 dols.); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (72*s.* 6*d.*)

Summary of Progress of the Geological Survey of Great Britain, and the Museum of Practical Geology for the Year 1953. *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*s.*)

Combines (Harvester-Threshers). U.S. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Industrial and Technical Assistance Division, by the U.S. Department of Labor. Distributed in Great Britain by the *British Institute of Management, Management House,* 8 *Hill-street, London, W.*1. (10*s.*)

Electric Power Transmission. The Power System in the Steady State. By Professors JOHN ZABORSZKY and JOSEPH W. RITTENHOUSE. *The Ronald Press Company,* 15 *East* 26*th-street, New York* 10, *N.Y., U.S.A.* (12.50 dols.)

Annual Report of the Chief Inspector of Factories for the Year 1952. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*s.* 6*d.*) [Reviewed in ENGINEERING, July 9, page 33.]

Physique Nucléaire. By THÉO. KAHAN. *Librairie Armand Colin,* 103 *Boulevard Saint-Michel, Paris.* (250 francs.)

Cours de Béton Précontraint. By J.-R. ROBINSON. *Dunod,* 92 *Rue Bonaparte, Paris* (6e). (960 francs.)

Technische Strömungslehre. By Dr.-Ing. BRUNO ECK. *Springer-Verlag, Reichpietschufer* 20, *Berlin W.*35. (29·40 *D.M.*)

EFFECT OF BOILER CAPACITY ON LOCOMOTIVE PERFORMANCE

SUPERIORITY OF LARGE BOILER REVEALED BY COMPARATIVE TESTS

By E. C. Poultney, O.B.E.

The significant effect of boiler capacity on locomotive performance has been convincingly demonstrated by the trials carried out by British Railways on two locomotives which have, to all intents and purposes, identical mechanical parts (cylinders, valve gears, etc.) but boilers of different sizes. The locomotives concerned were both War Department freight designs – one a 2-10-0 and the other a 2-8-0 – and the results have been published in one of the bulletins which British Railways have issued on their programme of locomotive trials.*

These locomotives were built for the Ministry of Supply during the 1939-1945 war from the designs of Mr. R. A. Riddles, C.B.E., and they took part in the Locomotive Interchange Trials inaugurated by the former Railway Executive in 1948. Originally the 2-8-0 engines were introduced to take the place of the L.M.S. 2-8-0 Class F8 locomotives, the 2-10-0 type following later with a lower maximum axle loading combined with a considerable increase in boiler capacity. Generally, they are much alike and, in respect to cylinder dimensions, piston-valve sizes, valve gears and the diameter of the coupled wheels, they are identical. As both types have the same working steam pressure, the tractive forces are also the same. The main difference is in the size and type of boiler, the 2-8-0 having a normal pattern of round-top boiler with the usual type of narrow firebox, while the 2-10-0 engines have a wide firebox, also of the round-top design, but with a short combustion chamber extending into the rear barrel section of the boiler. The wide firebox extends over the rear coupled wheels and provides a grate area of 40 sq. ft., compared with 28·6 sq. ft. in the case of the 2-8-0 engines. The leading particulars of the two designs are given in Table I.

TABLE I.—*Principal Dimensions of* 2-10-0 *and* 2-8-0 *Locomotives*

Type	2-10-0	2-8-0
Class	L.M.R. 8F	
Cylinders, dia. and stroke, in.	19 × 28	
Piston valves, dia., in.	10	
Driving wheels, dia., in.	56·5	
Boiler steam pressure, lb. per sq. in.	225	
Rated tractive force at 85 per cent. B.P., lb.	34,215	
Heating surfaces, sq. ft.—		
Tubes and flues	1,759	1,512
Firebox*	192	168
Evaporative, total	1,951	1,680
Superheater	423	310
Combined	2,374	1,990
Grate area, sq. ft.	40	28·6
Weights, tons—		
On driving wheels	67·15	62·0
Engine, total	78·3	72·0
Tender, loaded	55·5	56·0
Locomotive	133·8	128·0
Factor of adhesion	4·4	4·05
Boiler ratios—		
Firebox heat. surface/grate area	4·8	5·86
Evap. heat. surface/grate area	48·7	58·6
Comb. heat. surface/grate area	59·3	69·5
Superheating heat surface per cent. of comb. heat. surface	18·6	15·6

* On the 2-10-0 engine includes arch tubes

METHOD OF TESTING

All the trials were carried out on the Scottish Region between Carlisle and Hurlford, near Kilmarnock, on the old Glasgow and South Western main line, using the London Midland Region Mobile Test Plant comprising the L.M.R. No. 3 Dynamometer Car and Mobile Test Units Nos. 1, 2 and 3, together with a special tender having divided coal spaces, one for coal used during the actual tests and the other for that required for standing purposes. One complete trip from Carlisle to Hurlford and return was made each test day, and two controlled road tests were made in each direction of running. Both engines were tested using two different kinds of coal, over a range of constant speeds and at cut-offs varying from 15 to 60 per cent. with full regulator opening.

The 2-10-0 engine was tested at speeds of about 10, 20, 30, 40 and 46 m.p.h., when cut-offs ranged from 15 to 60 per cent. In the case of the 2-8-0, it was found impracticable to conduct tests at speeds over 40 m.p.h., nor was it possible to operate at 10 m.p.h. with a 60 per cent. cut-off due to excessive slipping. Rough riding prevented speeds higher than 40 m.p.h. Both engines have live-steam injectors of the Monitor type only, and both had 4⅞-in. diameter blast-pipe nozzles. Self-cleaning smokeboxes are not fitted. The 2-10-0 had a steel firebox, fitted with arch tubes. Both locomotives were given a general repair before testing and ran about 500 miles previous to the trials.

At the conclusion of the tests, the engines had each made a total of 3,500 miles approximately. In common with normal test procedure as practised by British Railways, measurements of the coal and water rates were by the Summation of Increments method, as developed at Swindon.

COALS

The two kinds of coal used were Blidworth Cobbles Grade 2B hard, and Blackwell B Winnings Grade 3B soft. Particulars of the calorific values of these coals are as follow:

Calorific Values, B.Th.U. per lb.

—	As received	Dry
2-10-0 *Engine:*		
Blidworth	12,800	13,500
Blackwell	11,800	12,350
2-8-0 *Engine:*		
Blidworth	12,490	13,350
Blackwell	11,750	12,500

Blidworth coal is common to all locomotive tests so far made; comparative results are therefore attainable. Blackwell coal was selected because it has a distinctive difference. Compared with Blidworth, it is of a poorer quality; it produces a considerable amount of non-porous clinker.

LOCOMOTIVE PERFORMANCE

The 2-8-0 locomotive steamed satisfactorily with Blidworth coal and the highest rate of evaporation at which a balance could be continuously maintained between the steam produced and exhausted and the demand, i.e., the "front-end limit," was 19,500 lb. per hour. The Blackwell coal could not be burned satisfactorily for extended periods and the maximum steam production sustained for 45 minutes was 13,000 lb. per hour. The restriction in the steaming rate was caused by deposits of clinker on the firebars, which restricted the supply of primary air, with a consequent drop in boiler pressure.

The 2-10-0 locomotive boiler, with the much larger grate area, steamed freely when fired with both kinds of coal. Maximum evaporations were 27,000 lb. of water per hour with Blidworth and 23,500 lb. with Blackwell coal. These evaporations marked the "front-end limit" in each case. Except for the wider operating range of the 2-10-0 engine, both engines showed very similar characteristics for water consumption and for indicated and drawbar tractive force and horse-power. This was, of course, due to both locomotives being identical except in the number of coupled axles and in the size of the boilers. The valuable feature of these tests is, therefore, the comparative performance data obtained with boilers having different steaming capacities.

COMPARISON OF BOILER PERFORMANCE

The evaporations obtained with the two boilers when each is fired with Blidworth and Blackwell coal are shown by Fig. 1, where evaporations are compared with hourly rates of firing. Fig. 2 shows the relative boiler efficiencies in relation to the coal fired in pounds per square foot of grate area per hour and the corresponding water/coal ratios. This plot does not include the results with Blackwell coal for the 2-8-0, which proved unsuitable for use with this engine.

An interesting point brought out by Fig. 2 is that the boiler of the 2-10-0 engine is for all practical purposes equally efficient when fired with both Blidworth and Blackwell coal. The relative water/coal ratios are, therefore, proportional to the respective "as fired" calorific values of the two different coals.

A comparison of the performance of the two boilers at the maximum and two lower and equal rates of evaporation is given by Table II. The comparison is made when both Blidworth and Blackwell coals are fired in the case of the larger (2-10-0) locomotives and for Blidworth coal only for the 2-8-0. The resistance through the boilers as indicated by the inches of water registered in the smokeboxes is of interest. The resistance of the boiler of the 2-10-0, having the longer tubes, is seen to be less than the 2-8-0 boiler

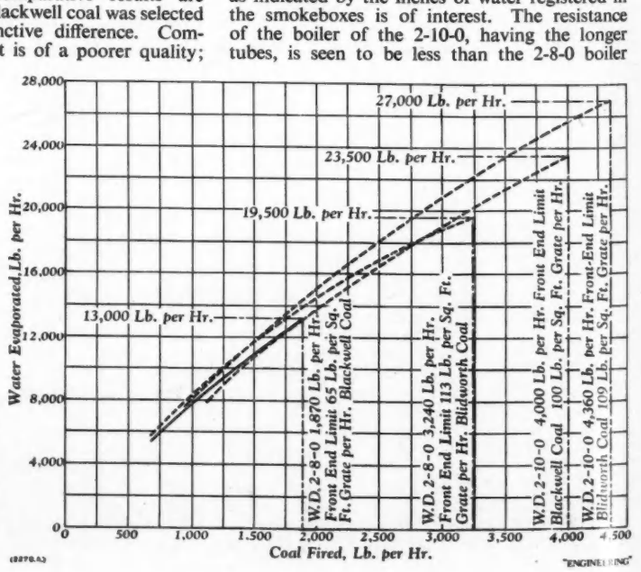
28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
Water Evaporated, Lb. per Hr.
27,000 Lb. per Hr.
23,500 Lb. per Hr.
19,500 Lb. per Hr.
13,000 Lb. per Hr.
W.D. 2-8-0 1,870 Lb. per Hr. Front End Limit 65 Lb. per Sq. Ft. Grate per Hr. Blackwell Coal
W.D. 2-8-0 3,240 Lb. per Hr. Front End Limit 113 Lb. per Sq. Ft. Grate per Hr. Blidworth Coal
W.D. 2-10-0 4,000 Lb. per Hr. Front End Limit Blackwell Coal 100 Lb. per Sq. Ft. Grate per Hr.
W.D. 2-10-0 4,360 Lb. per Hr. Front-End Limit Blidworth Coal 109 Lb. per Sq. Ft. Grate per Hr.
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
Coal Fired, Lb. per Hr.
(8270.A.)
"ENGINEERING"

Fig. 1 Maximum evaporation rates for the two boilers, plotted against hourly rates of firing.

* *Bulletin No.* 7. *Performance and Efficiency Tests with Live Steam Injector: W.D.* 2-10-0 *and* 2-8-0 *Freight Locomotives.* British Transport Commission, 222 Marylebone-road, London, N.W. 1 (10s. net).

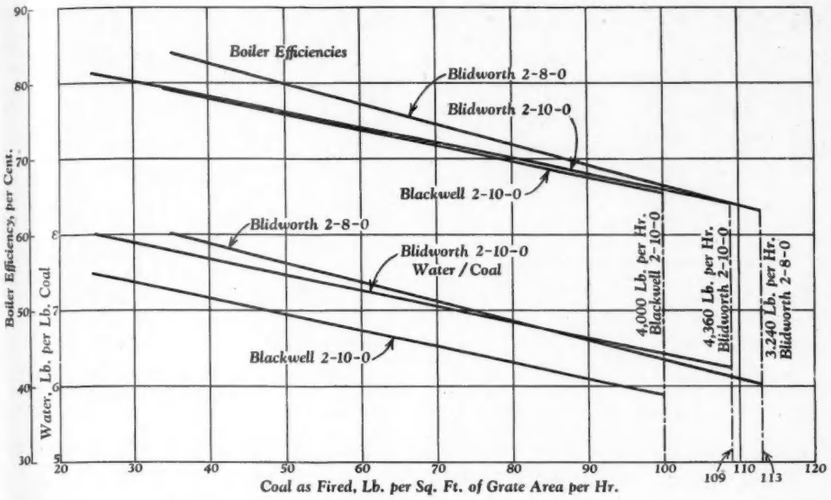

Fig. 2 Boiler efficiencies and water/coal ratios for the two locomotive classes. The larger boiler of the 2-10-0 is shown to be practically as efficient on the poor-quality coal (Blackwell) as on the good-quality coal (Blidworth).

having shorter tubes – a phenomenon which is presumably due to the larger grate of the 2-10-0 and, in consequence, possibly a thinner fire offering a comparatively low resistance to the flow of air. The length/bore ratios of the tubes are 110·3 to 1 and 93·3 to 1 for the 2-10-0 and 2-8-0 boilers and the total free gas areas through the boilers in relation to the grate areas are 11·6 and 16·8 per cent., respectively.

INDICATED HORSE-POWERS

The cylinders and related parts, coupled wheels and boiler working pressure being identical, it follows that at equal speeds and at the same rates of cut-off the steam flow to the engines, and the cylinder powers developed, must be equal. Thus any differences in the coal rate per indicated horse-power must be due to the boiler performance in respect to the relative water/coal ratios. On the assumption of a defined power output of 1,000 indicated horse-power at 25 m.p.h., the following data obtain:—

	Lb.
2-10-0	
Steam per hour	16,000
Coal per hour	2,150
Steam per I.H.P.-hour	16·0
Coal " " "	2·15
2-8-0	
Steam per hour	16,000
Coal per hour	2,330
Steam per I.H.P. hour	16·0
Coal " " "	2·33

There being such small differences in the calorific values of the coal (Blidworth in this instance), the thermal efficiencies of the power plants, i.e., boilers and engines, are for practical purposes proportional to the respective coal rates per cylinder horse-power hour. At the rate of cylinder feed assumed, the steam temperatures were practically the same, being 590 deg. and 600 deg. F. for the 2-10-0 and 2-8-0 engines, respectively.

DRAWBAR HORSE-POWERS

The powers developed depend on the steaming capacities of the boilers and, on the basis of the drawbar horse-powers, the 2-10-0 at the maximum evaporation of 27,000 lb. of water per hour developed a maximum of about 1,375 D.B.H.P. at 30 m.p.h. The coal fired, Blidworth, was 4,360 lb. per hour. The consumptions were, therefore, 19·6 lb. of water and 3·17 lb. of coal per D.B.H.P. hour. The same engine, when using Blackwell coal, developed a maximum of 1,250 D.B.H.P., also at 30 m.p.h., when the maximum evaporation was 23,500 lb. and the coal consumption 4,000 lb. per hour. The corresponding water and coal rates were therefore 18·8 and 3·2 lb. per D.B.H.P. hour.

Taking the 2-8-0 when using Blidworth coal at the maximum rate of evaporation of 19,500 lb. of water and a coal consumption of 3,240 lb. per hour, the maximum power developed was about 1,030 D.B.H.P. at 30 m.p.h. Thus the water and coal rates were 18·9 lb. and 3·14 lb. per D.B.H.P. hour.

It is interesting to note from the foregoing that, from the point of view of coal consumptions per D.B.H.P. hour, the large engine using the lower grade Blackwell coal (calorific value 11,800) shows closely the same coal consumption for the work done as the 2-8-0 using Blidworth coal (calorific value 12,490), when compared at capacity operation. Actually, the thermal energy consumptions per D.B.H.P. hour are 37,760 and 39,218 B.Th.U. for the 2-10-0 and 2-8-0 locomotives, equal to overall thermal efficiencies of 6·7 and 6·48 per cent. The 2-10-0 is therefore seen to be slightly more efficient than the 2-8-0 though using a coal of inferior heating value.

TABLE II.—Comparative Boiler Performances, 2-10-0 and 2-8-0 Locomotives

Locomotive and coal	Combustion: Coal fired, lb. per hr.	Combustion: Coal fired, lb. per sq. ft. of grate area per hr.	Combustion: Boiler resistance, in. of water	Evaporation: Water, actual, lb. per hr.	Evaporation: Water, equiv., lb. per hr.	Evaporation: Water, actual, lb. per lb. of coal fired	Evaporation: Water, actual, lb. per sq. ft. of heat. surface per hr.*	Evaporation: Water, equiv., lb. per sq. ft. of heat. surface per hr.*	Heat output, B.Th.U.: Total per hr.	Heat output, B.Th.U.: Per sq. ft. of heat. surface per hr.*	Boiler efficiency, per cent.
2-10-0 Blidworth	4,360	109	5·6	27,000	36,600	6·19	13·8	18·8	35,502,000	18,200	64·0
	2,500	62·5	3·0	18,000	24,000	7·2	9·3	12·3	23,280,000	12,000	73·7
	1,820	45·5	1·9	14,000	18,500	7·7	7·3	9·5	17,945,000	9,220	77·0
2-10-0 Blackwell	4,000	100·0	4·75	23,500	32,000	5·87	12·1	17·4	31,040,000	16,200	65·0
	2,780	69·5	3·2	18,000	24,400	6·45	9·3	12·5	23,668,000	12,190	72·0
	2,040	51·0	2·0	14,000	18,700	6·86	7·3	9·6	18,206,900	9,330	75·5
2-8-0 Blidworth	3,240	113·0	4·2	19,500	26,200	6·02	11·6	15·6	25,554,000	13,090	63·0
	2,810	93·0	3·65	18,000	24,400	6·40	10·7	14·5	23,668,000	12,190	68·0
	1,920	66·8	2·3	14,000	19,100	7·30	8·3	11·3	18,527,000	9,500	76·7

* Evaporative heating surfaces.

COAL CONSUMPTIONS AT EQUAL POWERS

2-10-0: *Blidworth Coal*
D.B.H.P. = 970. Steam per hour, 18,000 lb.
Coal per hour, 2,500 lb.
Coal per D.B.H.P. hour, 2·57 lb.

2-10-0: *Blackwell Coal*
D.B.H.P. = 970. Steam per hour, 18,000 lb.
Coal per hour, 2,780 lb.
Coal per D.B.H.P. hour, 2·86 lb.

2-8-0: *Blidworth Coal*
D.B.H.P. = 950. Steam per hour, 18,000 lb.
Coal per hour, 2,810 lb.
Coal per D.B.H.P. hour, 2·94 lb.

From the above it will be seen that, taking the case of the 2-10-0 engine, the coal rate per D.B.H.P. hour when using Blidworth coal is 2·57, as against 2·86 lb. for Blackwell. The former coal therefore gives an economy in consumption of 10·2 per cent. Now, comparing the 2-10-0 with the 2-8-0, both using Blidworth, the respective consumptions per D.B.H.P. hour are 2·57 and 2·94; the 2-10-0 is the more economical, showing a coal saving of 12·6 per cent. These comparisons are on the basis of practically equal powers at a common speed of 30 m.p.h. and in each case a cut-off of 30 per cent.

SUMMARY OF RESULTS

Summarising the overall results of these tests, the bulletin states that an average of 11·5 per cent. more Blackwell coal per D.B.H.P. hour was consumed by the 2-10-0 than with Blidworth. Also, the 2-10-0 consumed approximately 7 per cent. less Blidworth coal per D.B.H.P. hour than the 2-8-0 locomotive.

The foregoing computations, developed from the performance characteristics published in the bulletin, bring to notice the valuable nature of the test data obtainable by the use of the Mobile Test Units introduced by the former L.M.S. Railway at Derby, and are, moreover, a tribute to the skill of the operators. The comparisons obtained of the performances of the two locomotives clearly establish the advantages offered by ample boiler capacities, both as a means of widening the range of power output (and hence operating capacities), together with economical operation for the work performed.

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MEASUREMENT OF SMALL CURRENTS AND VOLTAGES

Vibrating-reed Unit

An instrument for measuring very small currents and voltages derived from a high-impedance source has been developed by Electronic Instruments Limited, Red Lion-street, Richmond, Surrey. It is suitable for measuring ionization currents of the order of 10^{-16} amperes.

The instrument is a vibratory condenser/direct-current amplifier embodying the "Vibron" condenser unit. This unit is mounted on a standard octal base and externally resembles a valve. The driving power is derived from the 6·3-volt supply which feeds the heaters of the amplifier valves. It is a vibrating reed unit and is capable of maintaining a zero stability within $\pm$ 100 microvolts over long periods, while the short-term stability is considerably better. All electrode surfaces are gold-plated and the whole unit is gas filled and sealed to prevent any deterioration in use.

There are three forms of amplifier incorporating the Vibron unit: for general purposes in the laboratory, an industrial pH meter, and a nucleonic weight gauge for use with beta-ray scanning equipment. The general-purpose instrument has input ranges of 10 mV, 100 mV and 1 volt, with an output of 1 milliampere for each. Input impedance is between 10^{13} and 10^{16} ohms, according to the application.

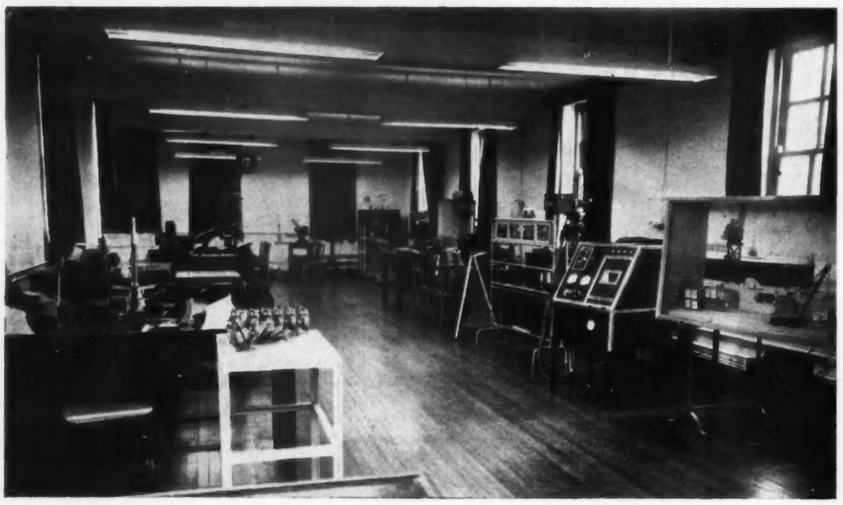


Fig. 1 General view of the Activity Laboratory.

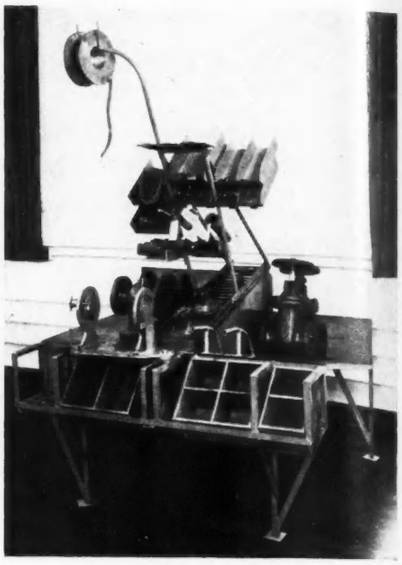


Fig. 2 Heavy handling operations, previously required in assembling the stop valve illustrated, have been eliminated and the time reduced from 15 to 2½ minutes.

RESEARCH AND TRAINING IN WORK STUDY

THE LABORATORY AT CRANFIELD COLLEGE

This article describes some of the activities of the laboratory at the College of Aeronautics, Cranfield, where students specialising in aircraft production and economics receive what is, perhaps, a unique introduction to work study, and where fundamental research into some of the human factors affecting work measurement has recently been initiated.

This laboratory, which has been described by some authorities as the best of its type anywhere, was developed by Mr. H. C. Wiltshire, M.Sc., M.I.Mech.E., M.I.E.E., M.I.I.A., who directs the instruction in work study in the department, of which he is deputy head.

When the department of aircraft production and economics was established at Cranfield, under Professor J. V. Connolly, F.R.Ae.S., M.I.Prod.E., in 1948, a motion and time study laboratory was set up for giving the students practical instruction in these subjects. The scope of the instruction given and the work carried out in the laboratory, however, soon began to develop along wider lines. In addition to providing a realistic approach to method study and work measurement, leading to consideration of incentive schemes and job evaluation, the two-year course offered to the aeronautical students places great emphasis on the importance of the worker, as an individual and as a member of a social group, and on the need for management to understand more about workers' reactions to supervision and to their fellow workers.

For instance, students are made familiar with the scope of the Hawthorne investigations carried out by the Western Electric Company of U.S.A. at their Hawthorne works. Investigations originally directed to determining the effect of shop lighting on output led – as a result of the anomalous findings obtained – to the initiation of a systematic research, in conjunction with the Harvard Graduate School of Business Administration, into the behaviour of the worker in his environment and into the social relationships involved. At Cranfield, a visual demonstration unit is used to assist in the exposition of this experiment and serves also as a constant reminder to those working in the laboratory of the importance of these human factors.

CASE STUDIES FROM INDUSTRY

This article, however, is concerned also with the practical applications of work study as carried out in the Cranfield laboratory, a general view of which can be seen in Fig. 1. The principles of method study, the improvement of production methods, the more effective arrangement of plant and materials handling, and the design of jigs and tools, are applied by the students, who work in groups of about ten on current case studies actually selected from industry. These examples, by no means confined to the aircraft industry, are deliberately selected for their difficulty and range from small precision electrical gear to heavy engineering components. Initially, the department found some difficulty in persuading industry to provide the students with such examples, but the results of the students' efforts have in many cases been so striking that industrial firms which previously showed little interest are now sending students to the Cranfield Work Study School. (The latter, which is separate from the two-year aeronautical course, was directed by Mr. Wiltshire at its inception under Professor Connolly, and is a course intended for industry generally.)

It may be of interest to cite some of the students' method study projects. From one of the more orthodox applications is a limit-switch assembly, the time for which was reduced from 22 minutes, at the manufacturers' works, to five minutes at Cranfield. In this example, the assembly process was designed, as far as possible, to provide identical motions for the two hands, the components being arranged sequentially in trays laid out to facilitate a rhythmical motion, as shown in Fig. 3. The assembly fixture, designed to suit the two-handed motion, allows some of the components to be located by touch. An air-operated screwdriver completes the set-up.

A less conventional application is the large valve assembly illustrated in Fig. 2. In the factory, up to 15 minutes were required for such valves. At Cranfield this time has been reduced to 2½ minutes. This remarkable saving has resulted from eliminating all heavy handling operations, for which an overhead crane had to be employed in the factory, by skilful design of the assembly jig.

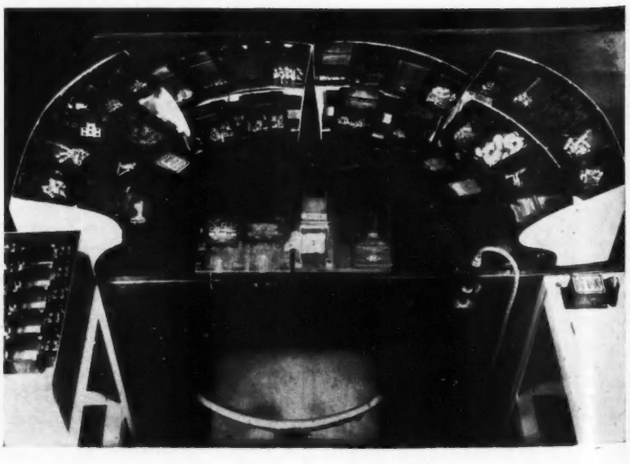


Fig. 3 An arrangement of assembly fixture, trays, etc., designed by students at Cranfield, which has reduced the time required for assembling a limit switch from 22 to 5 minutes.

Fig. 4 An example of a symmetrical two-handed layout : pistons being inserted in sets of piston rings which have been opened by a pedal-controlled mechanism.

The jig is arranged with a reception table at a convenient height to receive the heavier valve components from loading trolleys. From the reception table, the heavy valve body is rolled, without lifting, on to the assembly jig. The other parts are set out in trays at suitable heights. After assembly, the jig can be swivelled and tipped, discharging the completed valve on to guide rails which lead it to a delivery chute. The assembly jig can be quickly adjusted to take the various sizes of valve.

In Fig. 4 can be seen one of the current projects, a piston assembly and packing operation, which has not yet been quite completed. The problem of fitting the piston rings on the piston has, however, been solved very neatly. As performed at the manufacturers' works, a special tool was used for opening each ring for insertion in the groove; the operation called for a high degree of concentration and skill to avoid breaking the hardened rings.

The Cranfield students have developed an air-operated jig for two-handed operation, shown in Fig. 4, in which eight rings, that is, four per piston, are located in line. When compressed air is supplied to the jig, all eight rings are opened simultaneously, allowing two pistons to be inserted and located in the jig. When the air pressure is released, the rings snap home in the grooves. The assembly time per piston has been reduced from 18 seconds to 9 seconds and the operator's task has been rendered more pleasant. In this example, also, both hands are employed in symmetrical movements. Work is still in progress on the packing operations – wrapping the assembled piston in waxed paper and boxing it with a packet of circlips and an instruction sheet.

WORK MEASUREMENT

In order to provide a practical approach to work measurement, an experienced factory assembly worker is employed part-time to carry out assembly operations on the method-study projects. Thus, instead of applying work measurement techniques to their fellow-students' unskilled efforts, the students can time and rate the job as it would be performed by a trained operator at a production rate.

This operator also participates in establishing motion patterns on new jobs and in furnishing data for compiling "learning" and "performance" curves. On each job, assembly times are plotted against the number of components that have been completed at that time, with a view to establishing the way in which manufacturing man-hours are correlated with quantity – a question of importance in determining standard job times in those industries that are not concerned with long production runs.

It has been observed in the production of large units such as aircraft and ships that the performance curves follow a general pattern or trend. In many cases these curves approximate to a hyperbolic form represented by $y = a x^n$, where x is the number of units made, n a negative fractional constant, and y the time required to manufacture the xth product.

A performance curve obtained under controlled conditions of an assembly job in the Activity Laboratory is shown in Fig. 5. In this case the method has been maintained substantially constant and no fatigue effects are present. This curve was considered to correspond to a fairly high motivation on the part of the subject, because a monetary incentive applied for a short period during the investigation resulted in over-motivation and poorer performance, i.e., the rhythm of performance deteriorated.

A complete analysis was made in this investigation of the component element times, and the motion patterns were recorded as the performance improved. The corresponding performance curve is also shown in Fig. 5 after an interval of six months, during which time the subject had not performed the operation.

INSTRUMENTS FOR TRAINING IN TIMING AND RATING

A simple instrument has been devised and made at the College for training students in

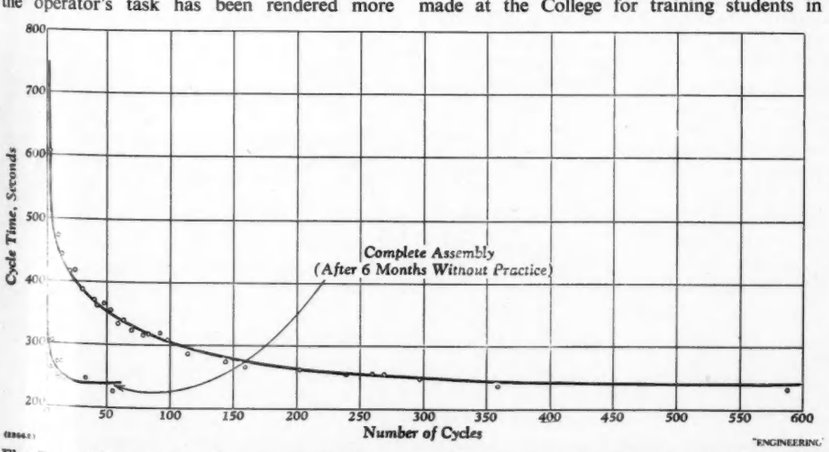


Fig. 5 Performance curve for an assembly job performed in the Laboratory under controlled conditions, showing the approach to optimum rate of working.

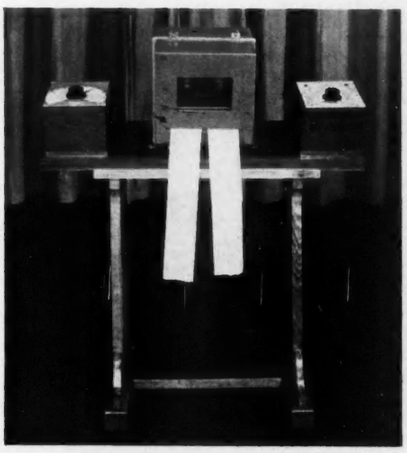


Fig. 6 Chart recorder for studying rating ability.

dexterity in handling a stop watch for work measurement. It consists of a synchronous motor driving a film strip at constant speed; the film strip carries a series of white marks at intervals. As consecutive marks pass a fixed registering mark on the casing, the student has to operate the watch to record the reading on the time-study sheet; since the motor speed is known, the students' time measurements can readily be checked for accuracy. Film strips of varying difficulty are used for assessing the competence of the student.

To check the students' rating of a sequential job in which each element is separately rated, a double chart recorder (Fig. 6) is employed. The movements of two styli are controlled by two dials, one operated by the instructor and the other by the student. Both dials are graduated in the rating units and the styli give an immediate graphical comparison of the instructor's and student's rating assessments.

It should also be mentioned that a practical approach to job evaluation is provided by requiring the second-year students to prepare a job evaluation scheme for the whole of the industrial workpeople in the College.

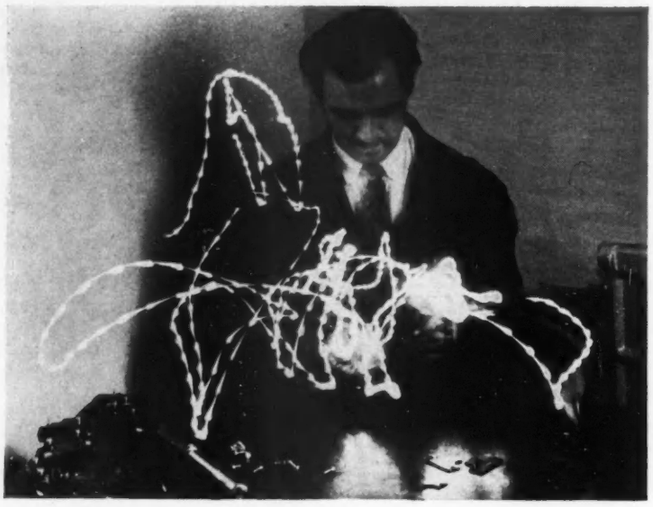
CYCLEGRAPH FOR RECORDING MOTION PATTERNS

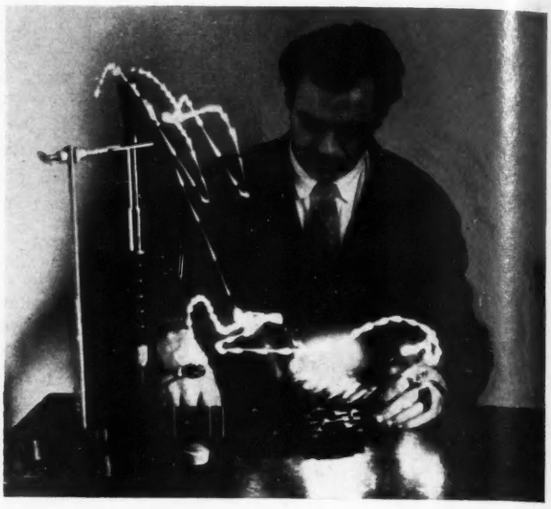
Several new types of instruments for training the students in work study techniques have been evolved in the laboratory. Motion-pattern records are valuable in leading the students to appreciate how a job can be carried out in various ways and with varying degrees of motion economy.

For recording motion patterns, a simple compact hand-held "cyclegraph" has been developed. The instrument case houses a translucent rotating disc of varying density which is rotated by a governed spring motor.

On the part of the body of which the motion patterns are required small lamps are fitted. When the instrument is held in front of the camera the effect of the rotating disc is to produce a series of flashes shaped like comets which indicate the path, speed and direction of movement. There is a choice of three rotational speeds, 20, 30 and 50 cycles per second, and it may be used with most types of single-lens cameras.

Further facilities provide for its use with two-lens stereo-cameras for producing three-dimensional records, and all such records in the laboratory are made stereoscopically. Typical motion patterns obtained with the use of this instrument are shown in Figs. 7 and 8. Fig. 7 shows the pattern of an operation before it was





Figs. 7 and 8 Motion patterns before and after an operation had been motion-studied. Small lamps are fitted on the operator's hands. A "cyclegraph," interposed between the hands and the camera, produces a series of flashes indicating the speed and direction of movement.

motion studied and Fig. 8 the result after improvements had been made.

One end of the laboratory is arranged as a projection booth for film and motion pattern analysis. For frame-by-frame film analysis, projectors have had counters fitted to them so that direct time readings can be made. This method is considered preferable to the old method used originally by Gilbreth of placing a special clock in the picture somewhere near the operator.

At the suggestion of the Cranfield authorities, Specto, Limited, Vale-road, Windsor, have recently produced a suitable frame-by-frame projector fitted with a counter, which now can be purchased as standard equipment.

Stereoscopic projection equipment is also available at Cranfield to project on a screen motion patterns which when viewed through polaroid glasses give a truer and fuller picture than that given by the usual two-dimensional projection. Furthermore, motion-picture films can be projected and viewed stereoscopically.

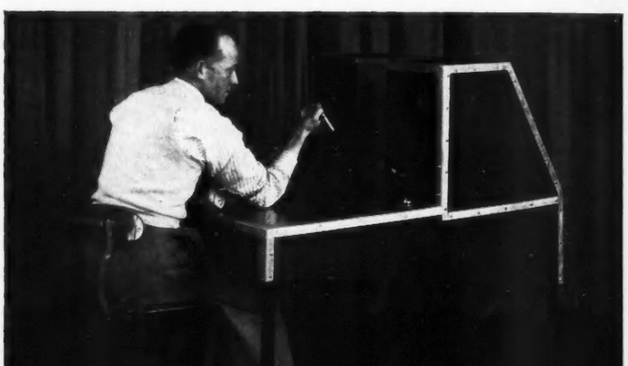


Fig. 9 Ergograph for recording fatigue. The resistance to the subject's manual effort can be varied by regulating the air pressure in a pneumatic cylinder. The amplitude of the work stroke is recorded by a stylus on a moving chart.

RESEARCH EQUIPMENT

In order to facilitate researches in the field of work study, equipment which is not normally available has been developed, and most of this equipment has been designed and made at the College.

Fig. 10 Dynamic reaction platform for measuring forces resulting from human work.

(i) *Analysis of Small Time Intervals.*—One of the more recent techniques which has become available is that known as "predetermined times." This technique is based on the principle that all manual work can be analysed into very small fundamental elements for which times of performance have been determined. To assess the time required for any job the particular elements are determined and their appropriate times added together.

To conduct research in this field requires fine measurement of time, for which photocell and lamp units have been developed at Cranfield. Two lamps direct beams of light through the area in which the subject's hands are working. For example, at the beginning of its travel the hand passes through one of the beams, the light

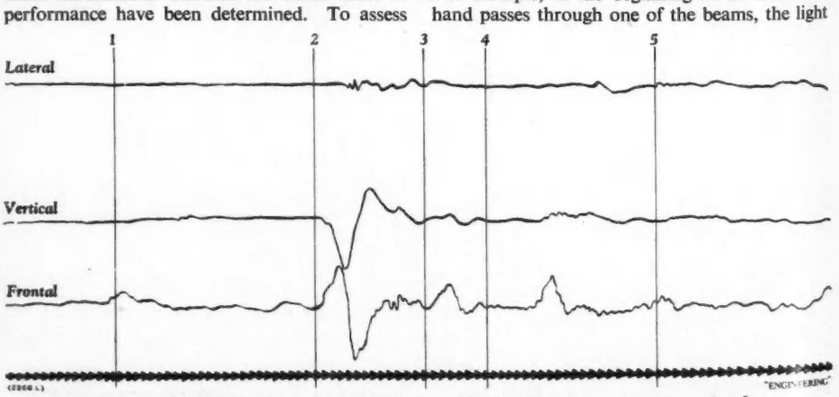


Fig. 11 Typical ergograph record for a subject performing a deep knee bend.

Fig. 12 Pulse counter. The operator's pulse beats, measured by a photocell clipped to his ear, are transmitted by radio to the observer.

falling on the corresponding photocell is interrupted, setting into operation an electric clock. At the end of its travel the hand passes through the other beam and the effect of cutting off the light from the photocell is to stop the clock. The time interval of the travel of the hand can thus be read on the hand of the clock.

An alternative circuit arrangement permits the clock to record the time the hand remains in the beam. On general work a clock reading directly to 0·01 sec. is employed, but finer measurements can be made by the use of recording apparatus.

(ii) *Fatigue Investigations.*—To assist in fatigue investigations a universal ergograph has been constructed and is depicted in Fig. 9. The human subject under investigation applies a rhythmic pull on the machine handle against the resistance of a pneumatic cylinder in response to a flashing light signal set by the investigator to the desired intervals. The resistance offered to the pull can be adjusted by regulating the air pressure. Two rings are provided, one suitable for finger operating and the other for whole arm or leg movement.

In one form of investigation the movement is continued until the subject reaches the limit of his endurance, which, it may be noted and can be demonstrated, varies with the "motivation" of the subject. As the subject becomes tired, the length of the work stroke, which is recorded by a stylus on a waxed paper chart, decreases. The total work done is shown directly by a separately calibrated counter. Another form of investigation uses the ergograph in conjunction with a pulse measuring device.

(iii) *Reaction Measuring Instrument.*—To measure the physiological reaction times to various forms of stimuli, including simple light and sound signals, a highly accurate electronic instrument has been developed at the College.

The subject under test is required to press a key in response to a signal and the time interval between the sending of the signal and the subject's reaction is indicated on the instrument dial. Some additional equipment provides more complicated displays in which, for example, a choice has to be made by the subject before responding.

PHYSIOLOGICAL RESEARCHES

The Activity Laboratory at Cranfield is doing pioneer work on physiological aspects of work study. The work being carried out at Cranfield, therefore, is at present aimed at exploring possible fields of profitable investigation.

Illustrated in Fig. 10 is a dynamic reaction platform developed at Cranfield and somewhat similar to an apparatus devised by Professor Soula and Mr. Lucien Lauru of the Centre National de la Recherche. The Cranfield machine comprises a platform suspended from a framework so that it can move horizontally and vertically under restraint. Electrical resistance strain gauges are mounted on the framework to record the three component forces when a human subject is working on the platform. (In the original machine piezo-electrical pick-ups were used instead of strain gauges.) The forces measured by the strain gauges are recorded by photographing their traces on a cathode-ray tube. Fig. 11 shows typical records obtained when a subject is performing a deep knee bend.

As part of a programme subsidised by the Department of Scientific and Industrial Research, two research scientists, Dr. R. M. Belbin from the Cambridge Applied Psychology Unit and Mr. J. A. C. Williams, recently commenced investigations into rest and fatigue allowances, that is, the allowances which must be made in assessing the work content of a job, taking into account the various factors of physical effort called for by the particular jobs. At present, such allowances are made empirically. In this work they are using a pulse counter which was developed from an instrument invented by Professor Müller of the Max Planck Institut für Arbeitsphysiologie.

In this instrument, illustrated in Fig. 12, the pulse beats are detected by a photocell which is attached to the lobe of the ear, variations in the density of the blood causing a fluctuation of the light received by the photocell. In the Cranfield pulse counter the photocell pulses are transmitted by a radio transmitter worn on the subject's back. The observer wears a corresponding receiver instrument, as shown in the illustration, thus allowing the subject to move unhindered while working.

FUTURE TRENDS

It is the opinion of the industrial engineering specialists at Cranfield that enormous potential increases in productivity are available in the United Kingdom by the application of known techniques and that there are factors very favourable at the present time to the wide adoption and application of work study. These factors are: (i) the urgent necessity for increased productivity; (ii) the existence of practically full employment; and (iii) the limited availability of capital for expanding industry.

There is evidence that industry is becoming increasingly "work-study conscious." The Cranfield laboratory, even in the short time since it has existed, is already making substantial contributions to the subject in the fields of teaching and research.

BARE CONDUCTORS FOR GENERATOR-TRANSFORMER UNITS

DESIGN AND ECONOMIC CONSIDERATIONS WHICH INFLUENCE CHOICE

By J. Bruce Laurie, B.SC., (ENG.), M.I.E.E.*

Technical improvements in the design of boilers and turbo-alternators have led the British Electricity Authority to standardise 60 and 100 MW units generating at 11·8 kV and 13·8 kV respectively for power station extensions. Further improvements, such as the use of a reheat cycle and hollow stator and rotor conductors, may introduce still higher capacities and result in an overall economy both in power station building volume per kilowatt and in other directions.

Present practice is to regard the turbo-alternator and its associated power transformer as a single solidly-coupled unit, although physically the two may be separated by perhaps 100 ft., and the problem is how the current – which may be of the order of 5,500 amperes, at 0·8 power factor – can be most economically transmitted over this distance.

Cambric-insulated cables have in the past been employed for this purpose for smaller capacity units. While the use of cables avoids the need for insulated supports it necessitates bulky multiple sealing ends at the generator and transformer terminals. Moreover, at present prices the use of cables tends to be uneconomic, especially at the high capacities involved. In this article, therefore, attention is confined to a discussion of the optimum bare-conductor arrangement† among the various alternatives available. As an illustration a 100-MW unit will be taken, corresponding to a current of 5,230 amperes, the material used being high-conductivity copper conforming to British Standard Specifications Nos. 1036 or 1037.

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THE BASIC PROBLEM

The current carrying capacity of bare copper conductors of a given section may be limited by: the maximum permissible temperature rise, from the point of view of the risk of oxidation at the joint surfaces; the relation between the annual interest and amortisation charges on the initial cost and the annual cost of the power dissipated in the form of heat; and the mechanical design. The thermal limitation gives the greatest economy in first cost, but, as will be shown later, it is not possible, in order to derive the greatest long-term economy, to make full use of the reduction in section that would be determined by thermal

† The term "bus-bar," as defined in British Standard Specification No. 159, is not strictly applicable here.

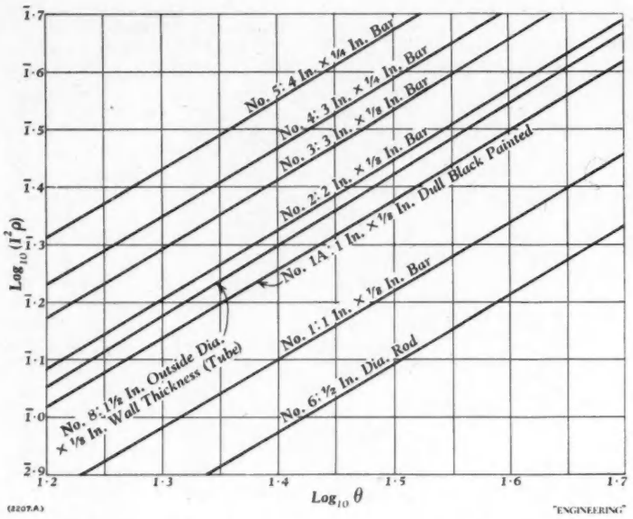

Fig. 1 Tests of current-carrying capacity of rectangular (solid and tubular) section high-conductivity copper conductors, showing relation between temperature rise and energy input.

considerations only. Mechanical design includes consideration of the maximum stress imposed under short-circuit conditions and of the distance between supports. These factors will not be considered further in this article, although in practice they should always be checked.

In accordance with British Standard Specification No. 159 of 1932, the maximum permissible temperature rise is assumed to be 50 deg. C. on an average ambient temperature of 30 deg. C. Even if the ambient temperature should reach a peak value of 40 deg. C. the calculated current rating would not be greatly affected. Above a maximum working temperature of 90 deg. C., however, the rate of oxidation of copper tends to increase rather rapidly. It is therefore usual to limit maximum bus-bar temperature to 90 deg. C. although sealing the joints can prevent any of the deleterious effects of oxidation on the contact resistance.

The thermal current rating of a bare copper conductor is obtainable by solving the energy-balance equation for the steady state. Once a steady temperature has been attained the rate at which electrical energy enters the conductor is equal to the rate at which heat energy is dissipated from its surface.

Hence,

$$I = \sqrt{\frac{W}{R}}, \qquad . \quad . \quad (1)$$

where I is the conductor rating, W the total rate of dissipation of energy per unit length and R the conductor resistance at the steady working temperature per unit length of conductor, in appropriate units.

As is well-known, energy is dissipated from a heated surface by convection, radiation and conduction, but mainly by convection and radiation, the relative amounts depending upon the shape, size and temperature of the conductor and its surroundings, as well as on the velocity of any cooling air currents and the nature of the conductor surface.

Careful study of the laws governing heat dissipation by each of the above means may result in considerable economies in the copper section selected for a given rating. For the present, it is sufficient to treat dissipation by both as "total" dissipation.

PRACTICAL TESTS

In order to establish the law connecting current-carrying capacity with temperature and geometrical conditions a series of tests was carried out by the National Physical Laboratory* on a number of copper bars of different shapes and cross-sections. The surfaces of all the bars were moderately tarnished and the conductors were carefully screened during the tests so as to allow free access of air while at the same time excluding draughts. The current-carrying capacities determined in this way ("still air" ratings) are therefore well on the conservative side for the majority of practical cases, although additional surface blackening and draughts would increase the rate of heat dissipation. The ambient air temperature was maintained at approximately 20 deg. C.

Bars about 12 ft. long were used, those of rectangular section being mounted on edge. Direct-current was passed through them until the temperature at the centre of the bars reached a steady value (as measured by embedded thermo-couple). The current was then increased until a further steady temperature was attained, and so on. Thus, assuming a value for resistivity, ρ, and temperature coefficient, α, of copper, it was possible to plot temperature rise, θ, as a function of energy input per unit length, W. Plotted on log scales, as shown in Fig. 1, it was found that the results fell on a series of straight lines of constant slope equal to 1·22. In other words, the power input, or rate of heat dissipation (per unit length), varied as the 1·22 power of θ and the current as the 0·61 power of θ.

It was also necessary to correlate the heat dissipated per unit area, h, with the conductor perimeter, p, giving

$$h = \frac{0{\cdot}0062}{p^{0{\cdot}22}}, \qquad . \quad . \quad (2)$$

for rectangular bars and strips, the relation being slightly modified for round conductors, both tubular and solid.

Thus $$W = ph\,\theta^{1{\cdot}22} = \frac{I^2\rho}{A}.$$

Substituting for h, this gives

$$I = \frac{24{\cdot}9\,A^{0{\cdot}5} \times p^{0{\cdot}39} \times \theta^{0{\cdot}61}}{\sqrt{(1+\alpha\theta)\rho}} \text{ amperes}, \quad (3)$$

where A is the conductor cross-section in square centimetres and α the constant mass temperature coefficient at the ambient temperature.

It is clear from this result that for a single bar maximum economy is obtained by using a section with the greatest possible perimeter per unit cross-sectional area; that is, a wide thin strip (with the longer dimension vertical) is superior to a solid circular section. It is also clear that there are limits to the amount by which the current-carrying capacity of a bar can be increased by increasing its thickness. Thus, increasing the thickness of a 4-in. by ¼-in. bar, for example, to 4-in. by ½-in., only increases the current rating by about 45 per cent., at the cost of doubling the amount of copper used. The use of a laminated arrangement of wide thin strips mounted on edge therefore seems most suitable for heavy currents, but is limited by considerations which are discussed later.

* *Copper for Bus-Bars.* The Copper Development Association (1954).

ALTERNATING-CURRENT LIMITATIONS

In view of the law governing the relation between current-carrying capacity and cross-section, as expressed in equation (3), it is most uneconomic to attempt to transmit a current of over 5,000 amperes through a single copper bar. Some improvement in ventilation is possible by lamination but no dissipation from the inner surfaces can take place by radiation, but only by convection. Consequently, in a group of laminated conductors, the inner bars become hotter than the outer. The laminated group will transmit more current than a single bar of the same aggregate section at the same maximum temperature; but four bars, for example, will only transmit about 3·2 times the current, that is, there will be a reduction in current density of 20 per cent.

In the case of alternating current, there are two effects which reduce the average current density still further, making the multiplying factor for four bars only about 2·3 instead of 3·2. Of these two effects, the first, "skin effect," influences the current distribution even in a single bar, by concentrating it round the edges. It thus raises the resistance R to a higher effective value, R′, increases the energy which has to be dissipated and so reduces the alternating current which can be transmitted for a given temperature rise.*

Further mal-distribution of current in laminated bars is caused by the "proximity effect." Generally speaking, this cannot be exactly calculated, though formulæ have been developed for certain conductor arrangements. It is sufficient to note that currents in the same direction in adjacent conductors, as in a laminated arrangement, give rise to flux-linkages, and hence to electromotive forces which concentrate the current in the outer parts of the laminations. The net result is that the central laminations only carry a small percentage of the total current.† Moreover, the currents in the individual laminations may differ in phase as well as magnitude, so that the losses in such an arrangement would clearly be considerable. Laminated bars are, in fact, never used for alternating currents in excess of about 3,000 amperes, for which up to four bars are required. For higher values of current, arrangements which will use the copper to better advantage must be investigated.

EQUI-INDUCTANCE LINES

Both skin and proximity effects are, of course, only different aspects of the same general phenomenon of electromagnetic induction. If it were possible, in a single-phase "go-and-return" circuit, to use bars of such shape that constant inductance existed between any point on one bar and any other point either on itself or the return bar, neither effect would arise. Alternatively, one effect would cancel out the other. Obviously, such a condition cannot exist in conductor sections of finite shape, but Arnold‡ has worked out the shape of infinitesimally thin (line section) conductors which would fulfil this condition. The resultant lines are called "equi-inductance lines." Their shape differs according to the spacing and can only be approached for actual sections. For close spacing long thin

* See M. B. Dwight. *Transactions American Institute of Electrical Engineers*, vol. 37, Part II, page 1379 (1918).

† See C. F. Wagner. *Electrical World*, vol. 79, page 526 (1922).

‡ See A. M. M. Arnold. *Journal Institution of Electrical Engineers*, vol. 80, page 395 (1937).

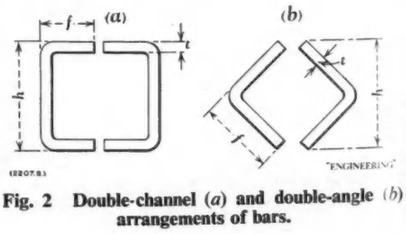

Fig. 2 Double-channel (*a*) and double-angle (*b*) arrangements of bars.

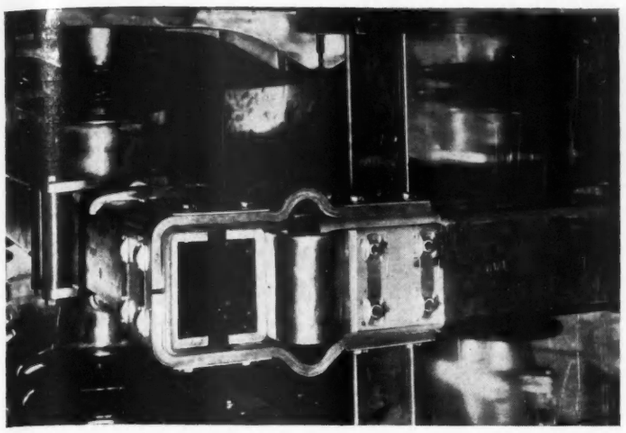

Fig. 3 Right angle expansion joint on copper channel bus-bars (I.T.E. Circuit Breaker Company and Anaconda Wire and Cable Company).

sections provide the closest approximation. As the spacing increases channel sections placed back to back approach the ideal, while for the wider spacings required for voltages of 11 kV or more the equi-inductance lines approximate to a circle.

FINAL CHOICE OF CONDUCTOR CONFIGURATION

The above theoretical consideration enables a further step to be taken towards the choice of the most efficient conductor configuration for a current of 5,230 amperes at 13·8 kV and suggests that a tubular section would most closely approach the ideal. This is partly true and tubular-section bus-bars are in fact capable, under identical conditions, of carrying about 25 per cent. more current than an arrangement of four laminated bars of the same aggregate cross-section. Nevertheless, this section is only ideal from the point of view of skin and proximity effects. The ventilation of the inner surface is far from ideal and the search for the most efficient bus-bar arrangement must therefore be carried yet another stage and the double-channel or double-angle arrangement considered, as shown in Fig. 2. Both these not only approach fairly closely the ideal Arnold case, but also provide adequate ventilation of all the surfaces. The improvement in current-carrying capacity over a four-bar laminated arrangement is striking and their use is essential when alternating currents of 3,000 amperes or more have to be carried. Up to the present, the double-channel arrangement has been more widely used than the double-angle. Fig. 3 shows a typical installation.

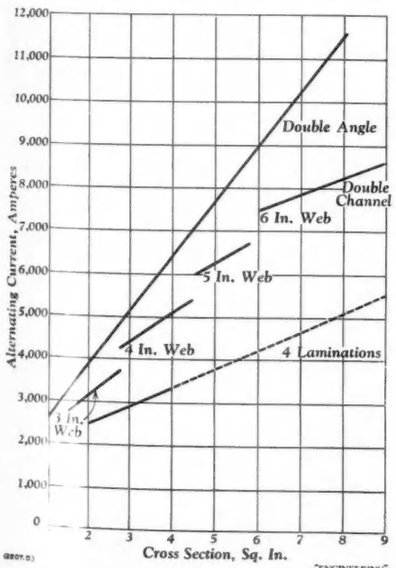

Fig. 4 Maximum thermal ratings of double-angle, double-channel and laminated conductors on alternating current for a 50 deg. C. rise on 30 deg. C. ambient temperature.

DOUBLE-CHANNEL AND DOUBLE-ANGLE CONFIGURATIONS

Coming now to the actual details of choice of section it is assumed for the moment that a double-channel arrangement has been selected, and that the current ratings are to be taken from a typical manufacturer's catalogue.* The test figures given in Table I have been extracted from this catalogue, the final column consisting of calculated figures, which will be referred to later.

From the data given in the table it is evident that for 5,230 amperes the choice would be a double-channel section 6 in. by 2$\frac{11}{16}$ in. by 0·276 in., with a total copper section of 5·84 sq. in., thus giving a current density of about 900 amperes per square inch. Before making a final choice, however, it is as well to see if still further economies can be effected.

The ratings given above are based on the United States practice of 30 deg. C. rise on a 40 deg. C. ambient temperature. Converting these to the 50 deg. C. rise on a 30 deg. C. ambient temperature, adopted at the beginning of this article, involves adjusting the maximum resistance from its 70 deg. C. figure to that at 80 deg. C. and allowing for the increased temperature rise of 50 deg. C. instead of 30 deg. C. The latter adjustment involves some assumption as to the exponent of θ in the relation between I and θ given in equation (3). The value established by the National Physical Laboratory was 0·61. From British Standard Specification No. 159: 1932, it follows that the exponent would be $\frac{1}{1{\cdot}15} = 0{\cdot}66$, although some engineers use a more conservative figure of 0·56. The National Physical Laboratory figure of 0·61 has, however, been widely employed since its establishment nearly 20 years ago and has been found to give results in accordance with practice. Fig. 1 shows that it remains constant in spite of variations in the shape and nature of surface. Applying a conversion factor based on this exponent to channel or angle sections would therefore appear to be reasonable and the rounded off figures of calculated current ratings given in Table I were obtained in this way. The conversion factor for the conditions given worked out at 1·344, that is, a 34·4 per cent. increase in current-carrying capacity.*

Referring again to Table, I, it will be seen that the channel section required would, under these conditions, be 4 in. by 1$\frac{3}{4}$ in. by 0·338 in., giving a total copper section of 4·44 sq. in. per phase. This does not, however, exhaust the possibilities of still further economies. A further increase in current-carrying capacity could be achieved, for example, by permitting the temperature to rise to a still higher value. The limitations to this would be: annealing, with a consequent deterioration of mechanical properties, and oxidation of the joint surfaces. An increase in temperature up to 165 deg. C. has, in fact, recently been advocated.† It would, however, have to be allowed for in the mechanical design and would very much depend on the quality of the joint, a matter which is fully discussed elsewhere.‡ Before such an expedient could be used for so vital a service as that now under consideration much more experience in higher temperature operation would, however, be required.

DOUBLE-ANGLE CONFIGURATION

Fig. 4 shows current-carrying capacities as a function of the cross-sectional area for double-angle and double-channel configurations, using a four-bar laminated arrangement as a basis of comparison. The last curve is shown dotted for sections greater than about 4 sq. in., because such an arrangement would not be used for currents over 3,000 amperes, as explained above. From this it will be seen that, with 4 sq. in. of copper, 3,400 amperes may be carried by four laminated bars, 5,100 amperes by a double-channel arrangement, 51 per cent. increase, and 6,400 amperes by a double-angle arrangement, giving a further increase of 20 per cent. on the double-channel and a total increase of 89 per cent. on the four-lamination arrangement, which was taken as the hypothetical criterion. It should also be observed that the curve for the double-channel arrangement

* See *Anaconda Bus Conductors*. Publication C25. Anaconda Wire and Cable Company.

* Direct experimental confirmation of this factor is at present being sought by means of further current rating tests on heavy copper sections.

† See H. A. Alder and K. H. Wadleigh. *Electrical World*, vol. 140, page 96, July 27 (1953).

‡ See *Copper for Bus-Bars*.

TABLE I.—Dimensions and Alternating-Current Rating of Single and Two Channel and Angle Conductors

Single Channel				Two Channel		
Height l	Flange Width	Thickness t	Area $\frac{A}{2}$	Area A	Approx. alternating-current Rating	
					Test*	Calculated†
In.	In.	In.	Sq. in.	Sq. in.	Amperes	Amperes
3	1$\frac{1}{16}$	0·216	1·07	2·14	2,500	3,300
3	1$\frac{1}{16}$	0·284	1·37	2·74	2,800	3,700
4	1$\frac{1}{2}$	0·240	—	—	3,500	4,700
4	1$\frac{1}{2}$	0·338	2·22	4·44	4,000	5,400
5	2$\frac{1}{16}$	0·260	2·24	4·48	4,500	6,000
5	2$\frac{1}{16}$	0·339	2·86	5·72	5,000	6,700
6	2$\frac{11}{16}$	0·276	2·92	5·84	5,600	7,500
6	2$\frac{11}{16}$	0·490	4·93	9·86	6,300	8,400
Single Angle			Two Angle			
3·19	2$\frac{1}{2}$	$\frac{5}{16}$	0·83	1·76	2,600	3,500
3·54	2$\frac{1}{2}$	$\frac{5}{16}$	0·92	1·84	2,750	3,700
4·25	3	$\frac{1}{4}$	1·48	2·96	3,650	4,900
4·95	3$\frac{1}{2}$	$\frac{1}{4}$	1·72	3·44	4,200	5,500

* 30 deg. C. rise on 40 deg. C. ambient. 50 deg. C. rise on 30 deg. C. ambient.

is a series of disconnected lines. These discontinuities take place at each change of height h; owing partly to the greater departure from the "equi-inductance" ideal as the thickness t, is increased and partly to the greater dissipative properties of a vertically placed, as opposed to a horizontally placed, rectangular section. Thus the greatest economy in channel sections is given by an optimum ratio of $\frac{h}{f}$ and a small value of t. Under these conditions the choice would be a double-angle configuration of two 3½ in. by 3½ in. by ¼ in. bars, reducing the copper section to 3·44 sq. in.

SURFACE BLACKENING

Finally, a detailed study of the nature of heat dissipation from a copper surface yields a further possibility of economy. In the National Physical Laboratory tests, mentioned above, both radiation and convection effects were considered together as "total dissipation." The two modes of dissipation, however, follow different laws. Thus, while convective dissipation is dependent on air movement, conductor geometry and temperature, dissipation by radiation is given by the well-known Stefan-Boltzmann relation:

$$H = 5{\cdot}72 \times 10^{-13} \epsilon (T_1^4 - T_2^4) \quad . \; . \; (4)$$

where ϵ is the emissivity coefficient, T_1 the absolute temperature of conductor, and T_2 the absolute temperature of surroundings.

A bright copper surface would have a coefficient of emissivity ϵ of about 0·2. In the National Physical Laboratory tests the bars used had a moderately tarnished surface, corresponding to a value for ϵ of about 0·35. All the current ratings considered so far have been based on this value. If, however, the value of ϵ could be raised the total heat dissipation for a given conductor surface and temperature rise would also be increased – though not proportionately, as radiation normally accounts for a comparatively small proportion of the total dissipation.

The limit of improvement by this means occurs when the surface approaches Boltzmann's ideal black-body radiator ($\epsilon = 1$). The term "black-body" may be a little confusing in connection with heat-emission, in that it implies that the surface should in fact be black, that is, a total emitter in the visual wavelength range. The true implication of this term is, however, that of total emission, i.e., emission at all, not only visual, wavelengths. What is important in connection with the low-temperature emission associated with current-carrying conductors is that it shall occur at the wavelength associated with energy emission at the conductor operating temperature, not in the visual range. This is confirmed in practice, where it has been found that the surface condition is of more importance in approaching the condition of $\epsilon = 1$ than the actual colour of the surface. A dull mat surface is more efficient than a glossy one.

The findings of Melsom and Booth* on this point were confirmed by National Physical Laboratory tests, curve 1A in Fig. 1, showing a 39 per cent. increase in heat dissipation and 18 per cent. in current-carrying capacity due to dull black painting, over the same bar unpainted, as indicated in curve 1. At least one manufacturer has put this principle into practice. The method of dipping bars in "liver of sulphur" (potassium sulphide) is, however, of limited efficacy as it only brings the value of ϵ up to about 0·48, while coating with a dull mat paint is capable of increasing it to as high a value as 0·98. A further method of increasing the emissivity is that known as "black anodising," or controlled oxidation in a caustic soda bath. The very tenacious film of black cupric oxide formed in this way gives protection against further oxidation and has an emissivity coefficient which approaches unity.

* See S. W. Melsom and H. C. Booth. *Journal of the Institution of Electrical Engineers*, vol. 62, page 909 (1924).

The improvement in rating caused by painting or black anodising will not be so great in the case of double-channel or double-angle arrangements as that for rectangular bars, since the inner surfaces are less effective radiators than the outer. Nevertheless, some improvement is undoubtedly possible and by this means one size of smaller double-angle bar, 3 in. by 3 in. by ⅛ in., would be more than adequate to transmit the 5,230 amperes under the conditions specified. The copper section per phase would be only 2·96 sq. in., though consideration of the losses, as set out below, leads to some modification of this conclusion.

For 60-MW alternators, operating at 11·8 kV and 0·8 power factor similar considerations to the above would lead to the choice of 2½ in. by 2½ in. by $\frac{3}{16}$ in. double-angle bars, again subject to modification in cases where the losses are important.

ECONOMIC CONSIDERATIONS

The ratings so far considered have been the maximum thermal ratings. They are based on still-air conditions and are therefore likely to be conservative in practice, since a comparatively small air movement is capable of removing quite large quantities of heat from the surfaces of bare conductors. On the other hand, if ventilation is restricted full advantage cannot be taken of the economies put forward above. An installation designed in accordance with the principles discussed would therefore appear to be attractive. Between the cable arrangement mentioned at the outset of the article and the mat-painted double-angle conductor arrangement there is an economy of no less than 60 per cent. in copper cross-sectional area per phase.

There is indeed no reason why copper conductors of the section and configuration determined by the above considerations should not be run up to their maximum thermal ratings, thus permitting the high current density of 1,520 amperes per square inch, provided the loss load factor is not so high that the annual cost of the losses, plus that of the annual interest and amortisation charges on the bus-bars (less allowance for scrap), does not exceed a minimum value. In other words, Kelvin's Law becomes operative at high load factors. The conclusions reached in the preceding sections must therefore be reviewed in the light of this law, and if possible the section chosen which will achieve the minimum total cost.

This is done in tabular form in Table II, which gives the figures actually used in connection with the main conductor design for a recent generating station project. The following notes will assist in the interpretation of this table: the conductor arrangement is twin-angle per phase.

TABLE II.—ECONOMIC COMPARISON OF MAIN CONDUCTOR SIZES FOR 100 MW AT 13·8 KV, 0·8 POWER FACTOR. DOUBLE-ANGLE ARRANGEMENT.

Conductor Size	Section	Resistance	Losses	Weight	Cost	Annual Charges (£)				
						Capital		Losses	Total	
						(a)	(b)		(a)	(b)
In.	Sq. in.	Ohm × 10^{-3}	kW	Lb.	£					
3½ by 3½ by ¼ ..	3·44	0·1985	16·32	2,785	750	62·2	56·6	221·6	283·8	278·2
4½ by 4½ by ¼ ..	4·30	0·1588	13·16	3,477	878	72·9	66·0	178·7	261·6	244·7
4½ by 4½ by $\frac{5}{16}$ ..	5·38	0·1270	10·44	4,348	1,044	86·6	77·9	141·8	228·4	219·7
6 by 6 by $\frac{5}{16}$ ..	7·24	0·0943	7·75	5,860	1,280	106·2	94·5	105·2	211·4	199·7
6 by 6 by ⅜ ..	8·69	0·0788	6·48	7,035	1,582	126·2	112·1	88	214·2	200·1

TABLE III. ECONOMIC COMPARISON OF MAIN CONDUCTOR SIZES FOR 100 MW AT 11 KV, 0·8 POWER FACTOR. DOUBLE-CHANNEL ARRANGEMENT.

Conductor Size (in.)	Section (sq. in.)	Annual Charges (£)				
		Capital		Losses	Total	
		(a)	(b)		(a)	(b)
4 by 1⅝ by 0·338	4·44	74·8	67·6	171·5	252·1	244·9
5 by 2⅛ by 0·315	5·32	87·5	78·5	148	235·5	226·5
6 by 2⅛ by 0·276	5·84	92·1	82·7	131	223·1	213·7
6 by 2⅛ by 0·350	7·22	109	98	107	216	205
7 by 3⅛ by 0·325	8·1	118·6	105·4	94	212·6	199·4

TABLE IV.—*Economic Comparisons of Main Conductor Sizes for 100 MW at 11 kV 0·8 Power Factor – Tubular Bus-bars.*

Conductor Size (in.)		Section, sq. in.	Annual Charges (£)				
			Capital		Losses	Total	
External Diameter	Thickness		(a)	(b)		(a)	(b)
5	0·3	4·43	46	39	175·5	221·5	214·5
5·5	0·3	4·90	51·3	43·4	158	209·3	201·4
5·5	0·348	5·63	60	51	138	198	189
6	0·45	7·85	89	77	97	186	174
6	0·5	8·64	103	89	90	192	178

Other configurations are summarised in Tables III and IV.

As the conductors will not be operated at their maximum permissible temperature, an arbitrary figure of 70 deg. C. has been assumed in the calculation of resistance and losses, though the larger-sized bars will tend to run at an even lower temperature than this, as may be calculated from formula (3). In making the final comparison of annual charges the cost of the losses may therefore be adjusted by approximately 4 per cent. for every 10 deg. C. by which the assumed operating temperature differs from 70 deg. C. Direct-current resistances are used, on the assumption that the configurations employed are a sufficiently close approach to the equi-inductance line condition for skin and proximity effects to be ignored. The figures for section and resistance are per phase and the length of conductor assumed is 70 ft., as in the case of the particular station for which the table was drawn up. Losses and weights are three-phase.

CAPITAL CHARGES

The capital charges are approximate only and are based on manufacturers' estimates for 12-ft. lengths at a time when electrolytic wire-bar was quoted at £231 10s. per ton. The annual interest and amortisation charges are calculated at the rate of 8·3 per cent. in accordance with present practice in these matters. For bare copper conductors a scrap allowance may also be made. At the time of writing, scrap quotations are within about £10 per ton of the wire-bar price. Over a period of, say, 25 years, however, the price offered can only be estimated and a round figure of £200 per ton has therefore been assumed. Allowance for scrap is then made by deducting from the annual interest and amortisation charges a figure corresponding to 4½ per cent. of the total scrap value, calculated at compound interest on a 25-year basis. Annual charges with and without scrap allowance are

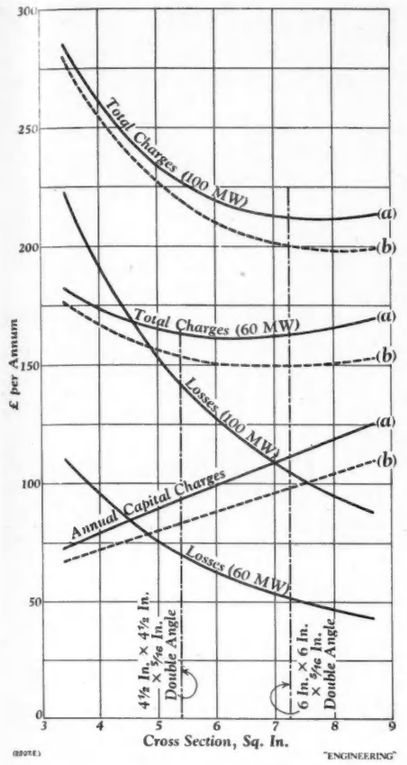

Fig. 5 Economic conductor section for 60-MW and 100-MW generators (*a*) without and (*b*) with an allowance for scrap.

given in columns (*a*) and (*b*), respectively, of Tables II to IV. The cost of supports for a given voltage do not vary greatly with the conductor section and are therefore not considered, as they do not affect the optimum Kelvin section. Various power station erection costs show that these also vary but little with the copper section. Neither erection nor dismantling costs are therefore included in the analysis.

The exact monetary value at which to assess the losses is a matter of some difficulty, and has been discussed elsewhere.* Evidently the load factor applicable to the losses, which are proportional to the square of the load current, will not be the same as that of the load current itself. Calling the load factor l, the loss load factor will lie somewhere between l and l^2, depending on the ratio of the root mean square to mean value of the load curve. Various empirical formulæ have been proposed to evaluate the loss load factor and in the present calculations it has been taken as $0{\cdot}5l + 0{\cdot}5l^2$. Assuming that British Electricity Authority base-load stations are to be operated at a load factor of 0·85 the loss load factor therefore becomes 0·786. A further difficulty centres on whether any fixed charge should be included in the estimate of conductor losses. It might at first sight appear unreasonable to do so, the difference between the losses on a 100 MW set when using the smallest and largest sections under consideration (about 8 kW), being insignificant in comparison with the generator output. Certainly no physical saving in generating plant would be involved. Nevertheless, the view must be taken that the British Electricity Authority sells kilowatts as well as kilowatt-hours and that the conductor losses, small though they may be, represent so much lost revenue on both these commodities. A capital charge must therefore also be included in the loss estimate. This is estimated at about £60 per kW, with interest and amortisation at 8·3 per cent. as before.

The interpretation of Tables II to IV will depend on general financial policy. Taking a long-term view, however, the figures suggest that it is worth increasing the initial expenditure on the conductors in order to reduce the losses. Making due allowance for scrap, following the other assumptions already mentioned and plotting the data of Table II as shown in Fig. 5, it now appears that the optimum selection of bare conductor section should be 6 in. by 6 in. by $\frac{5}{16}$ in. twin angles for 100 MW sets and 4½ in. by 4½ in. by $\frac{5}{16}$ in. twin angles for 60 MW sets. Tables III and IV summarise the data for other configurations, the optimum sizes being determined in a similar manner to that just described. Table V summarises the final results.

It will be observed from Fig. 5 that the minimum point in the total cost curves does not occur when the annual interest and amortisation charges are equal to the annual cost of the losses, as in the elementary case of Kelvin's law. It is displaced to the right of this point due to the constant content in the manufacturing costs. The cost of bending, for example, varies but little with the section, while rolling and/or drawing costs may even decrease as the sections increase.

Moreover the minimum point in the curve of total annual charges is by no means well-defined and a good deal of latitude is thus permitted in the final selection of the section. In practice, the nearest practicable size to the left of the minimum is chosen, so as to err, if at all, on the side of lower first cost It will also be observed that allowance for scrap, though appreciable, is not sufficient to influence the practical choice of section. The losses may be adjusted in accordance with the estimated working temperature (formula 3) but here again the position of the minimum point is not affected sufficiently to influence the practical choice.

TABLE V.—*Proposed Standard Sections.*

—	60 MW	100 MW
Double-angle ..	4½ in. by 4½ in. by $\frac{5}{16}$ in.	6 in. by 6 in. by $\frac{5}{16}$ in.
Double-channel	5 in. by 2$\frac{5}{8}$ in. by 0·315 in.	6 in. by 2$\frac{11}{16}$ in. by 0·35 in.
Tubular ..	5·5 in. external diameter by 0·348 in.	6 in. external diameter by 0·45 in.

On the other hand, it should be remembered that the larger the section of the conductor, the cooler it will run – a point which might be of value in cases of restricted ventilation.

ECONOMY LIMITATIONS

The economies discussed in the earlier part of this article cannot therefore be made use of in their entirety in the particular case under discussion. This, however, does not mean that all the measures discussed need be abandoned, as the following considerations will show. Whether the section is selected on the basis of first cost or in accordance with Kelvin's Law, it is always advantageous for the copper to be distributed where it is most usefully employed. In other words the conductor configuration must always approximate to the equi-inductance line ideal. If it does not, the effective resistance will be higher than the direct-current resistance, the cost of the losses will be higher than the values given in Tables II and III and a larger copper section will be necessary.

Thus the conclusions relating to the inapplicability of laminated bars to heavy alternating currents still apply. As between double-channel, double-angle, circular, square tubular or other arrangements, the choice is likely to be dictated more by economic considerations, similar to those summarised in Table I, and by convenience in arranging the supports, and condenser bushings, than by conditions of ventilation, as affecting maximum thermal rating. The relative efficiency of the ventilation of the various conductor configurations only governs their operating temperature, which, when the section is selected in accordance with the economic considerations set out in Table II, is likely to be well below the 50 deg. C. rise normally permitted and so of no particular importance. As a second-order effect, the operating temperature will, of course, affect the cost of the losses to a small extent – which is another reason for inclining rather to the left of the minimum point in the total-loss curve (70 deg. C.) when making the final selection. This means that a tubular section conductor, which would have had to be ruled out had thermal limits and first cost been the only considerations, may now be considered.

Table IV summarises the economic analysis for extruded tubular conductors. From this it appears that a 6 in. diameter tube with a wall thickness of 0·45 in. would be suitable for 100 MW and a 5·5 in. diameter tube with a wall thickness tube of 0·348 in. for 60 MW generators. As the thermal ratings of these tubes are 5,520 amperes and 4,430 amperes respectively, it will be appreciated that they will run rather hotter than the double-angle or double-channel arrangements considered above: probably with temperature rises of about 45 deg. C. and 35 deg. C. respectively. Similarly the question of black anodising or otherwise improving the surface emissivity of the conductors together with black painting of the chase walls or other surrounds will be of importance, not in increasing the maximum thermal rating, but in lowering the operating temperature.

METHODS OF MANUFACTURE

It will be appreciated from the foregoing section that Tables II and III are not exhaustive, but apply only to the particular types of section shown, when manufactured by press-braking from cold-rolled strip; or hot-rolled and pickled in the larger sections. Other configurations, or even alternative methods of manufacture of the same configurations, require a separate study on the lines of Table II in order to select the optimum section.

The method of manufacture is of importance for other reasons. Manufacture by press-braking from strip, as in Tables II and III involves a length limitation of, in general, 12 ft., which may or may not be convenient, depending on the nature of the conductor run between generator and transformer terminals. Press-brakes are, however, now available in this country which are capable of dealing with lengths up to 20 ft. When manufactured in these longer lengths costs would tend to be greater and hence the section selected smaller, than that based on Tables II or III. Alternatively, at least one British manufacturer is equipped to produce sections and configurations of the type required by means of the process of direct extrusion and drawing. This results in considerably cheaper manufacturing costs for the smaller sizes shown in Tables II and III. The economics of extrusion and drawing are, however, dependent on the diameter of the circumscribing circle of the section and costs rise rapidly with increasing diameters. For the larger sizes given in Tables II and III there is probably little to choose between press-braking and extrusion. The latter process has the advantage, however, in that far longer lengths – at least 20 ft. – may be dealt with than is normally possible by means of the press-brake. Another advantage is that there is no reason, when this method is used, why the section should be limited to angle or channel shapes. Dies may be cut by an automatic profile-follower, which accurately reproduces the shape of a wooden pattern. The production of bars, the shape of which is very close to the ideal "equi-inductance line" therefore becomes possible – though the complications in supports and connectors entailed by so doing might nullify the advantage gained of minimum alternating current resistance. The extrusion process is also applicable to tubular conductors, as shown in Table IV.

STANDARDISATION

In this, as in other matters, the importance of standardisation in reducing costs should be

* H. Waddicor. *Electric Power Transmission*, page 280. Chapman and Hall.

carefully considered. With the prospect of a fair tonnage of conductors for 100-MW and 60-MW sets, manufacturers are able to spread their tool costs, with a consequent reduction in cost per foot of conductor. Bearing the above points in mind, the sections shown in Table V would appear to be the most satisfactory and might well be regarded as standards: Of these, the double-angle arrangement, given its lower operating temperature, might be considered to have the advantage, but much will depend on the connection arrangements.

CONCLUSIONS

The problem of the selection of the most economical bare conductor arrangement for generator/transformer connection in power stations is one which can best be approached by a systematic consideration of the various factors affecting bare conductor design: heat dissipation by convection and radiation, thermal limitations, skin and proximity effects. These considerations lead in a logical manner to the selection of a double-angle arrangement as being by far the most efficient, the second place being taken by the double-channel, while the tubular type has advantages, especially where condenser bushings are concerned. An economic analysis in accordance with Kelvin's Law then determines the optimum size of each configuration to adopt, as given in Tables II to IV. Methods of manufacture affect the initial cost, though not to any great extent in the larger sizes as determined from Kelvin's Law. In the interests of standardisation and consequently of economy in first cost, it is advisable to restrict the bare conductor sizes used to one of each type for each size of generator, as shown in Table V, while, of these, the choice might be restricted still further to the type possessing the best overall advantages, that is, the double-angle.

While generators up to 200-MW capacity are already at an advanced stage of design, standardisation of conductor sizes for these larger sets would appear to be premature for the time being, at all events until the generating voltage is settled. The matter should, however, be approached on similar lines to the above.

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WINDOW CONTROL

Use of Flexible Cables

Bowden cables form the operating link in a system of window control introduced by Henry Hope and Sons, Limited, Smethwick, Birmingham. Where one casement only is to be controlled, operation is by a handle which slides in a vertical groove. A thumb-operated catch holds the window in any position. Where two or more windows are to be controlled from a single position, a gearbox driving a traversing connection is used. This is self-locking. No special sub-frame or lining is required at the windows, with the exception of those with bottom-hung casements. The operating cable can be concealed behind plaster or panel-work in the same manner as an electric conduit, and the square outer tube, of sheradized steel, can be bent to conform to the window shape. The limiting radius for bends is 2·5 in.

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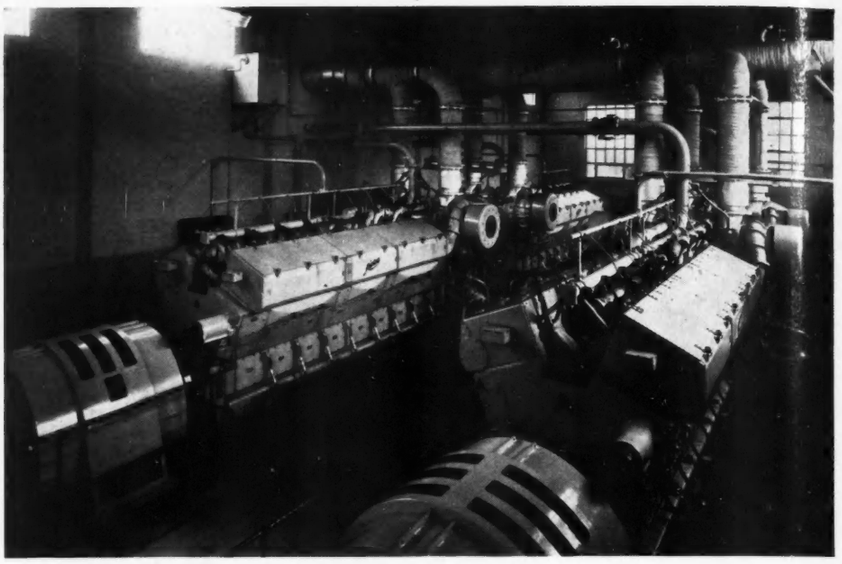
NEW CABLE FACTORY

Southampton Chosen for its Transport Facilities

Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, are to erect a factory at Southampton New Docks for the production of submarine telephone cables and submerged telephone repeaters.

Southampton has been selected for this purpose because of its excellent rail and sea access, both of which are important in the manufacture and shipment of this type of cable and equipment. In particular, the good docking arrangements will facilitate the loading of the British Post Office cable ship Monarch.



Four Mirrlees-Brush 1,064-kW Diesel-alternator sets, shown here, are installed at the engine division's East Works power station. Two similar units are installed at the Filton aeroplane works.

AUXILIARY ELECTRIC POWER

DIESEL-DRIVEN PLANT AT AIRCRAFT WORKS

Believed to be the largest private Diesel generating plant set up in any British factory since the second World War, the 10·25-kV installation at the Filton and Patchway works of the Bristol Aeroplane Company, Limited, Bristol, comprises three separate stations which are connected in parallel with the main 11-kV distribution system. It is operated in close collaboration with the South Western Electricity Board, who welcome the additional generating capacity available for use at times of peak load as well as to meet standby requirements.

The first of these three stations was put in hand as a result of the power crisis caused by the shortage of coal and generating plant during the winter of 1946-47. Three direct-current 1,200-kW generating sets, originally spares for American naval frigates, were installed at the Gypsy Patch site in the Engine Division, and were running before the end of 1947.

Within a few years it became necessary to increase the capacity of the supply from the Electricity Board to more than twice that used in 1947, and it was decided that the company's standby power supply should be increased. Six 1,000-kW Diesel alternator plants were therefore added in 1953, four were installed at the Engine Division's East Works and two at Filton to serve the Aircraft Division. The operation of all three stations is controlled from the East Works power station.

Apart from the main factory's installations, there is also a fourth and much smaller station of 216 kW which serves the company's engine overhaul shops at Whitchurch.

DIRECT-CURRENT SETS WITH COMPRESSED-AIR STARTING

The prime movers of the three 1,200-kW direct-current sets are General Motors 16/278A two-stroke uniflow scavenge 16-cylinder Diesel engines, of 1,700 h.p. each, equipped with direct-driven Roots type scavenge blowers.

Each engine is started by compressed air at between 300 lb. and 600 lb. per square inch, and compressed-air equipment is available for six to ten starts without recharging. The compressor is a two-stage Reavell unit driven by a 30-h.p. slipring alternating-current motor, and a standby petrol-driven unit is installed, which will top up the storage bottles for one or two starts.

The engine-cooling system comprises closed-circuit heat exchangers with Heenan and Froude mechanical forced-draught coolers handling the secondary water, which is pumped by electrically driven Worthington-Simpson pumps. The jacket water is circulated by engine-driven centrifugal pumps.

The lubricating-oil system employs the dry-sump principle with a 300-gallon electrically heated tank mounted in an adjacent pit. The oil is reconditioned by means of a De Laval centrifuge.

Fuel oil is stored in two 12,000-gallon cylindrical tanks at the rear of the station and is pumped to two 500-gallon service tanks mounted on a steel girder platform within the station, whence it feeds the engine by gravity.

The Allis-Chalmers generators operate at 500/550 volts at 700/750 r.p.m., and the field is separately excited by direct-driven exciters. These machines are highly rated and are small in size for the output of 1,200-kW. To cater for the high temperature rise – 70 deg. C. above ambient – glass-fibre insulation is used, and the heat is dissipated by passing the cooling air in a closed system through a water-cooled radiator mounted on top of the generator-field yoke.

The generators, which are of the double-pedestal bearing type, are lubricated from the engine lubrication system, and are connected to the engines by a short length of shafting and a flexible coupling.

In the case of sets 1 and 2, the output from each machine is taken to a change-over switching cabinet in an adjacent sub-station, and is fed to the direct-current side of a rotary converter. The current is inverted, transformed up to 11,000 volts, and switched on to the high-tension distribution network through C-type Reyrolle O.C.B. switchgear.

The output of No. 3 set is brought to the direct-current bus-bars in the sub-station and can be used either entirely locally or fed to a rotary converter.

It is not possible to switch No. 2 set to the local direct-current load, but No. 1 set can be connected by means of a solid link to a special consumer unit at 500 volts direct current, independent of the main board, when it supplies a stable voltage for test purposes; it is used considerably in this manner. The maximum load required of the set in this form, however, is only 500-kW.

DIESEL-ALTERNATOR SETS

Situated in the East Works are four Diesel-alternator sets of 1,064-kW capacity each, commissioned in 1953.

The prime movers are Mirrlees, Bickerton and Day JVS.16 Diesel engines. This engine is a 16-cylinder four-stroke turbo-charged unit developing 1,520 brake horse-power at 750 r.p.m., with a 12-hour rating in accordance with B.S. 649/1949. The Brown-Boveri exhaust-gas turbo-chargers operate on the Buchi principle.

Engine cooling is by a closed-circuit heat-exchanger system. One end of a twin Safran centrifugal pumping unit, driven by a 10-h.p. Brush motor, circulates the engine-jacket water. The other end pumps raw water, cooled by a Heenan and Froude evaporative-type mechanical cooler through twin lubricating-oil coolers and then through vertically-mounted heat exchangers or, by way of a by-pass valve, back to the cooler.

Lubricating oil is stored in a twin-compartment tank, one side for new and one for reconditioned oil, or, alternatively, for use as a transfer tank when any one or two sumps require emptying. A De Laval-type 1,700 centrifuge is used to reclaim the heavy-duty lubricating oil and for transfer duties.

Two 12,000-gallon horizontal cylindrical storage tanks hold the bulk fuel oil, which is transferred to two 500-gallon daily-service tanks on the annexe roof. These tanks are fitted with automatic fuel-oil transfer-pump control gear.

All the engine auxiliaries except the lubricating-oil priming pumps are housed in an annexe on the north side of the main power station. The annexe also accommodates a workshop and a store, and, isolated from the main pump room and engine hall, a fuel-injector-nozzle reconditioning unit and a test rig for fuel injectors, which handles all the various fuel-injector nozzles used in the factory, including mobile units for aircraft-engine starting duties.

The Mirrlees engines are started by compressed air, supplied from three 11-cub. ft. air receivers. A Broom and Wade electrically-driven compressor is used for charging the receivers and a combined 6-kW alternator air-compressor unit, driven by a Petter A.2 10-h.p. Diesel engine, is available for emergency duties.

The engines are coupled to Brush salient-pole type single-pedestal-bearing 3·3-kV alternators with overhung exciters. Their output is transformed up to 11 kV through solidly-coupled Brush auto-transformers, and switched onto the 11-kV network through remotely-operated Reyrolle " C "-type switchgear.

The controls for the four sets are grouped at a central station. An audible and visual alarm system operates in the event of low lubricating-oil pressure, failure of water circulation, and high water-outlet temperature.

The four-generator sets are controlled from a switch panel at the load control centre, which is located at one end of the station about 12 ft. above floor level. The panel is equipped with the necessary switches and instruments for paralleling, synchronising and remotely closing the main distribution switchgear. The engine load/speed mechanism, voltage and power-factor rheostat are also controlled from the desk through geared motors protected by limit switches.

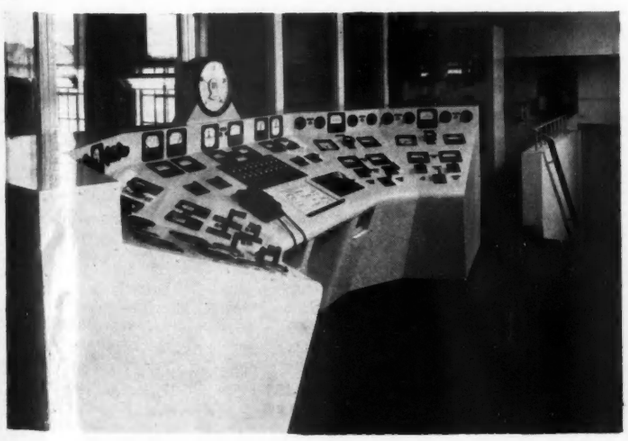
The exciter-field rheostat, field-suppression switch and earthing changeover links are housed in small cabinets, one cabinet containing the equipment for two engines.

The Filton power station is similar to the East Works layout but contains only two Mirrlees/Brush JVS 16/1064-kW alternator sets, with provision for installing two further sets if required. House supplies and power for emergency operation of the solenoid-operated Reyrolle switchgear is derived from a 45-kW self-contained alternator set with sufficient capacity to carry the complete services of the power station and certain adjacent services in the event of emergency.

LOAD CONTROL CENTRE

As previously indicated, the load-control centre in the East Works is the headquarters of the load control. All the information covering the loading of the works electrical-distribution system is grouped on the load-control desk.

This information indicates to the operator the demands made by various sections of the works – in particular the turbine-test department – so that he can control the supply to maintain a balanced system and a controlled maximum demand. Power-factor correction condensers, recently installed at the various sub-stations to maintain economical use of power, are controlled from this desk, as are also the starting and stopping of the nine Diesel-alternator sets. To achieve this a telegraph system communicates with the three main generating stations by light signals, which indicate the number of sets to be started and stopped. The communication system radiating from this centre comprises private telephone lines connecting the high-tension substations and key personnel.



The central control room; from this desk are controlled all nine motor-generator sets serving the factory.

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RUBBER IN LIQUID FORM

A Versatile Material

Lorival Plastics, Little Lever, near Bolton, Lancashire, are now producing liquid depolymerised natural rubber in two viscosities; Lorival R.25 rated at 25,000 poises and Lorival R.5 at 5,000 poises. Both forms are fluid at room temperature and may be stored for long periods without deteriorating.

Liquid rubber is useful as a softener in raw-rubber processing, in which it is vulcanised into the end product. It is particularly valuable with synthetic rubbers, sponge, or expanded-rubber stock. It also has applications as a master-batch medium for paints, dyes, and inks, for imparting " cling " to lubricating materials, and for improving the ability of graphite compounds to withstand high pressures.

Thinned, sprayed on metal and then stoved, Lorival R provides a coating that is chemically resistant to almost all corrosive agents. When mixed with aluminium flake and treated in the same way the resultant finish will resist red heat.

The two standard types of Lorival R are supplemented by a range of liquid-rubber compounds known as Lorival CR containing sulphur and various fillers. They can be stored in a cool place for about six months.

CR compounds have applications as in adhesives for rubber-to-metal bonding: as a binder for grinding wheels, for anti-static rubber products, corrosion-resistant linings, vulcanising cements, for printing rollers, embedding electrical circuits and for coatings.

The most important use for Lorival CR, however, is probably as a fluid casting material. This method of producing rubber articles, hard or soft, is the cheapest available both for batch or bulk quantities. No elaborate mixing plant is necessary and no moulding presses are required.

The compound selected is poured into a simple mould of wood, plaster, cement or mild steel and vulcanised in an oven at 150 deg. C. or at lower temperatures for longer periods. After a suitable time has elapsed the product may be removed from the mould and replaced in the oven for the remainder of the curing time. The resultant shrinkage in the finished article can be as low as 0·1 per cent. and the same mould may, therefore, be recharged every few hours. The application of a varnish to the face of a mould made from porous substance is, of course, necessary to prevent adhesion.

Articles too large for conventional moulding presses can be made in this way and their finish, though dependent on the mould, is good.

★ ★ ★

ELECTRICITY SUPPLY IN JUNE

8·8 Per Cent. Increase

During June, 1954, 4,597 million kWh were sold by the British Electricity Authority to the Area Boards. This was an increase of 9·7 per cent. over the figure of June, 1953. When corrected for the weather and the number of working days, which were less than last year, the increase was 8·8 per cent. The amount of electricity sent out by the Area Boards was 4,502 million kWh and 95 million kWh were supplied direct by the Central Authority. The amount distributed to the " mainly industrial " areas was 2,927 million kWh, and to the " mainly non-industrial " areas 1,575 million kWh.

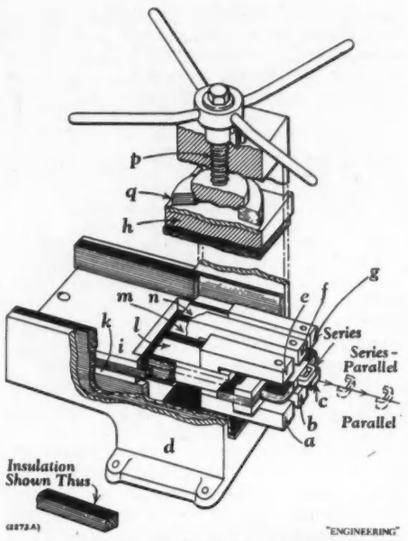


Fig. 1 The electrical resistance of this switch is kept to a minimum by high contact pressures, which are released before the switch is operated.

SWITCH FOR HEAVY CURRENT TESTING

Low-Voltage Transformer Work

By H. A. SMITH, A.S.T.C.*

A switch has been developed to make the necessary changes for supplying the heavy currents used in current transformer testing from a power transformer with four 3-volt, 750-ampere secondary windings, which can be connected in series, series-parallel and parallel.

A design using conventional knife-blades would have required six large, single-pole, double-throw switches. This type of switch has a low contact pressure in order that the blades can be moved without scoring when it is operated. It has been shown† that the contact resistance per unit area of a copper-copper contact is inversely proportional to the pressure. For low contact pressures the area must therefore be large to give the very low resistance necessary for heavy currents. The switch described below consists of small copper blocks clamped together with a pressure of 1,000 lb. per square inch. This pressure must be released before the contacts are moved to another setting.

COMPACT DESIGN

The construction of the switch is shown in Fig. 1, where *a*, *b* and *c* are copper contacts fixed to the body; *d*, *e*, *f* and *g* are contacts fixed to the block *h*; and *i*, *k*, *l*, *m* and *n* are contacts fixed together to form a unit which slides between the contacts secured to *d* and *h*. A lever, not shown in the figure, is connected to the eye *o* and is used to slide the unit to any one of the three positions shown. In the drawing the switch is in the series position.

Pressure is applied by means of the screw *p* and is transmitted by the uniform-section disc spring‡ *q* to the contact assembly. The spring consists of six discs arranged in a stack giving a stiffness six times that of a single disc. This type of spring is ideal for the switch because the dimensions can be chosen so that over a wide range of deflection the load is practically constant. This allows dimensional changes to occur in the parts of the switch, due to wear and heating, without affecting the pressure on the contacts. In addition, it fits compactly into the space above the block *h*. The average load-deflection characteristic for the whole spring is shown in Fig. 3. Owing to friction between the discs the actual load for any deflection may differ from that shown on the curve by as much as ± 10 per cent. The dimensions of a single disc are also given in Fig. 3.

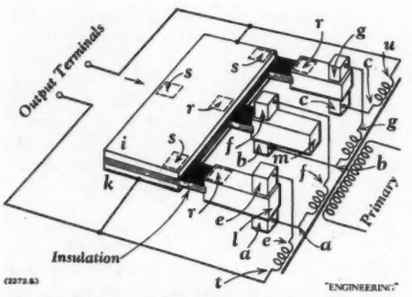


Fig. 2 Diagram of switch contacts and connections for series, series-parallel and parallel positions.

The contacts are connected to the transformer windings by flexible conductors as shown in Fig. 2. When the sliding unit is located so that the two sets of contacts *e*, *f*, *g* and *a*, *b*, *c* occupy the positions on the sliding contacts as shown, the transformer windings are connected in series; if they occupy the positions marked *r* the windings are connected in series-parallel; and if they occupy the positions marked *s* the windings are connected in parallel.

In order that the four windings might share the load equally when in parallel, the impedances of the four paths were equalised by keeping the flexible conductors from *t* and *u* close to the others coming from the transformer. The working temperature of the switch was reduced by painting it dull black and covering the flexible conductors with thin black polyvinylchloride tubing.* In a test at full load current the final temperature rise of a covered flexible conductor was 50 deg. C., whereas that of an uncovered conductor was 65 deg. C.

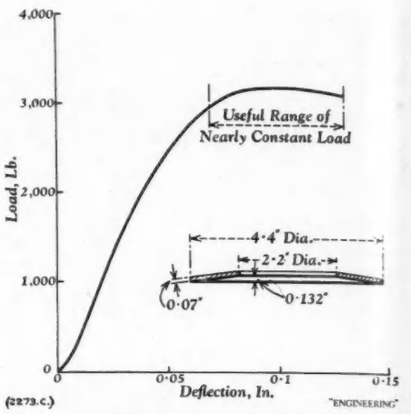


Fig. 3 Load-deflection characteristic of a uniform-section disc spring made up of six discs in parallel. Inset is a section of a single disc.

SERVICE BEHAVIOUR

When operating at 750 amperes per square inch, the switch contacts reached a final temperature of 70 deg. C. in still air at 20 deg. C. The measured mean value of the contact resistance was initially 3 microhms per square inch and after one year of normal service in the laboratory this had increased to 5 microhms per square inch. Where atmospheric conditions are more severe it might be desirable to silver-plate the contact surfaces in order to maintain a low contact resistance.

In the application for which the switch was designed it is normal practice to disconnect the transformer primary from the supply before changing the secondary connections. A switch was arranged to do this automatically by mechanically linking it with the handwheel of the secondary switch. The short-circuiting of the windings as the switch is operated is therefore no disadvantage. If it were necessary to use this type of switch on a live circuit it should be possible to arrange for the contacts to lift apart before they slide.

* Mr. Smith is with the Division of Electrotechnology, Commonwealth Scientific and Industrial Research Organisation, Sydney, Australia.

† Melsom, S. W., and Booth, H. C. *Journal of the Institution of Electrical Engineers*, vol. 60, page 889 (1922).

‡ Almen, J. O., and Lasglo, A. *Transactions of the American Society of Mechanical Engineers*, vol. 8, *page* 4 (1936).

* Melsom, S. W., and Booth, H. C. *Journal of the Institution of Electrical Engineers*, vol. 62, page 909 (1924).

LAUNCHES AND TRIAL TRIPS

S.S. "HADRA."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Shell Tankers, Ltd., London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,000 tons on a draught of 29 ft. 6 in. Double-reduction geared steam turbines and two Foster Wheeler oil-burning boilers, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne; and installed by the shipbuilders. Service speed, 14½ knots. Trial trip, June 28.

S.S. "LOUIS TRICHARDT."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for Irvin and Johnson, Ltd., Cape Town. Main dimensions: 141 ft. between perpendiculars by 27 ft. by 14 ft. to main deck; gross tonnage, about 490; fishroom capacity, 5,910 cub. ft.; capacity of offal room, 2,708 cub. ft. Separate quarters provided for European and native crews. Triple-expansion steam engine constructed by Charles D. Holmes & Co., Ltd., Hull. Steam supplied by one coal-burning Scotch boiler. Launch, July 1.

M.S. "BRITISH CORPORAL."—Single-screw oil tanker, built and engined by Harland and Wolff Ltd., Belfast, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 490 ft. between perpendiculars by 65 ft. by 36 ft.; deadweight capacity, about 14,000 tons. Harland-B. and W. six-cylinder single-acting two-stroke opposed-piston Diesel engine. Trial trip, July 1.

M.S. "THESSALONIAN."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for Sir Thomas Robinson and Son (Grimsby) Ltd., Grimsby. Main dimensions: 115 ft. between perpendiculars by 25 ft. by 12 ft.; gross tonnage, 275. Four-cylinder direct-reversing Diesel engine, developing 575 b.h.p. at 225 r.p.m. in service, constructed by British Polar Engines Ltd., Glasgow, and installed by the Drypool Engineering and Dry Dock Co., Ltd., Hull. Launch, July 2.

M.S. "AGHIA MARINA."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Porto Blanco Compania Naviera S.A. (Managers: Rethymnis and Kulukundis Ltd.), London, E.C.3. First vessel of an order for three. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 30 ft. 6 in.; deadweight capacity, 11,120 tons. Doxford four-cylinder opposed-piston oil engine. Service speed, about 13¾ knots. Trial trip, July 5.

M.S. "WHITBY ABBEY."—Single-screw cargo vessel, built by Hall, Russell & Co., Ltd., Aberdeen, for Associated Humber Lines, Hull. Main dimensions: 256 ft. overall by 38 ft. 6 in. by 21 ft. 6 in. to shelter deck; deadweight capacity, 1,240 tons on a draught of 13 ft. 5 in. Kincaid-Polar marine Diesel engine, developing 2,100 b.h.p. at 220 r.p.m., constructed by John G. Kincaid & Co., Ltd., Greenock. Trial trip, July 7.

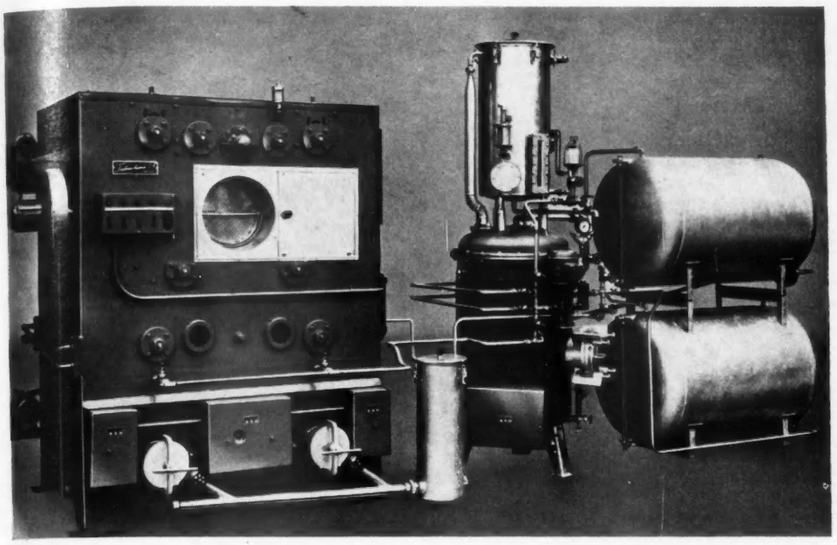


Fig. 6 This totally enclosed degreasing machine with its accompanying still has been designed to use as little as 5¼ gallons of trichlorethylene per week when in full production.

THE PRODUCTION EXHIBITION

Concluded from page 71

Our article on the first Production Exhibition, held at Olympia from July 7 to July 14, is continued below with descriptions of some more of the exhibits, all but two of which are illustrated on the accompanying pages.

DEGREASING PLANT

The totally-enclosed degreasing machine which we illustrate in Fig. 6 has been designed to operate with the minimum consumption of trichlorethylene. With the added use of a still, consumption can be kept as low as 15 gallons per week with the machine on full production. As a guide, 12 cwt. of work can be handled in one hour. A further feature of the design is that there is no leakage of fumes, so removing any risk normally incurred by the operator of this type of equipment. Moreover, the possibility of fumes attacking machines in the vicinity is removed. This particular machine is made in Switzerland but is available in this country through the Electro Chemical Engineering Company, Limited, 161 Queen's-road, Weybridge, Surrey.

The machine consists of a degreasing tank which is divided into two or more compartments, each with a cleaning manhole for the removal of solid residue and with the necessary connections for changing solvents. Heating is carried out either electrically, with a thermostatic control, or with low-pressure steam, the normal operating temperature being 85 deg. C. Vapour given off by the solvent is condensed by a cooling system above the tank level and returned to the final bath. A thermostat is also fitted to cut off the heating system in the event of a failure in the supply of cooling water. Water and soluble oil are separated from the solvent by means of a special filter.

The upper part of the machine contains the mechanical parts and the loading and unloading station is to one side at a convenient height. Two endless conveyor chains, linked by traverse arms, carry the work-basket holders. The work baskets are normally of cylindrical shape and are made from perforated stainless steel. The conveyor chains are driven by an electric motor, through a reduction gear.

The sequence of operations is synchronised. As soon as a basket holder arrives at the loading and unloading point, the conveyor chains are stopped. The basket containing degreased and dried materials is removed manually and a basket of unprocessed work inserted in its place. During loading and unloading the other baskets remain immersed in the degreasing tanks or in the drying zone.

The baskets may also be rotated whilst they are in the machine, at the times when the conveyor chains are stationary. A separate drive motor is provided for their rotation. The advantage of this additional feature is that the work is more thoroughly washed, resulting in more effective cleaning and drying, particularly when recessed parts are being treated. Their rotation in either of the tanks or the drying compartment can be stopped by a push-button control, and similar controls are provided for the conveyor. Electric lights are fitted internally and an inspection window is provided for observation of the baskets during their passage through the machine. When the loading door is opened a curtain of air is automatically blown across the aperture, this, and the arrangement of the cooling coils, resulting in the complete absence of smell through leakage of fumes.

Several sizes and types of this machine are being made, and a typical specification of this machine, the Jura-O, is a follows: with 2 tanks and 3 basket holders (baskets 12 in. diameter by 16 in. long) and 12-kW heaters, the overall dimensions are 6 ft. 6 in. by 3 ft. 9 in. by 6 ft. 6 in. high; output is about 40 baskets per hour, each basket containing from 10 to 45 lb. of work.

PLATING BARREL

The Electro-Chemical Engineering Company, Limited, were also showing a portable plating barrel, which is particularly suitable for firms wanting to barrel plate small batches of work in one or more processes. As can be seen from Fig. 7, it is a self-contained unit constructed throughout from Perspex – which is suitable for operating in temperatures up to 180 deg. F. Known as the Efco-Udylite PX 12, it can be operated single-handed for continuous production using hot alkaline cleaners, water rinses, acid dips and acid- or alkali-plating processes, including stannate tin. It comprises a hexagonal plating cylinder which is rotated through a Perspex ring gear by a small electric motor mounted above the plating cylinder.

The cathode contacts are of the flexible type, designed to give an effective current distribution and to be readily removable for stripping. The panels of the plating cylinder are drilled with $\frac{3}{16}$-in. holes giving approximately 30 per cent. open area.

The work is plated while it is contained in the cylinder. For loading and unloading there is a removable panel with a quick-release device. The internal dimensions of the plating cylinder are 12 in. long by 6 in. in diameter, providing a capacity of 340 cub. in. The average weight of work that can be processed in one batch is 15 lb., and the complete machine weighs 39 lb. The work can be passed single-handed through the pre-cleaning and plating processes, and rotation of the cylinder during the cleaning and rinsing operations results in very effective cleaning, an important feature when bright nickel-plating. The normal speed of rotation is 12 r.p.m. A safety plug is provided for connecting the driving motor to the supply.

TIN-NICKEL ALLOY PLATING

Electrodeposited tin-nickel alloy plate was introduced about two years ago as a decorative and protective coating. When deposited by electro-plating on a polished metal surface, the finish is bright and, there is, therefore, little or no need for buffing or other treatment. The most outstanding property of the plate is its resistance to tarnishing in which respect it is as serviceable as chromium. The plate is claimed to have a more attractive colour than either chromium or nickel; the blue and yellow tints respectively associated with these metals are absent, whereas the alloy plate has a faint rose-pink tint which is generally regarded as pleasing and attractive. The plate is harder and more durable than either tin or nickel and is considerably more resistant to attack by many corrosive media. During the exhibition, the Tin Research Institute, Fraser-road, Greenford, Middlesex, who developed this process, were demonstrating it with the aid of a small automatically-operated plating machine.

The alloy deposited by the process described

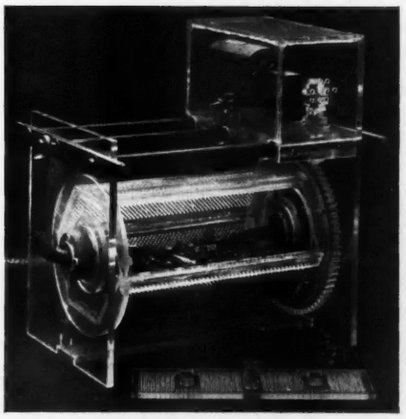


Fig. 7 Made of Perspex, this portable plating barrel can be used at temperatures up to 180 deg. F. It can be used successively for washing, rinsing and then plating.

Fig. 8 The top of the work table on this induction heater can be removed to give access to a sink for quenching work.

below contains approximately 65 per cent. of tin and 35 per cent. of nickel. Examination shows that these figures correspond quite closely to an equi-atomic ratio, and experience is that the process favours the co-deposition of tin and nickel atoms at identical rates.

Tin and nickel are both fairly resistant to corrosion, but each metal tarnishes in the air and the initial brilliance obtained by polishing or other means is soon lost. Tin and nickel form an alloy series characterised by a number of intermetallic compounds, which can exhibit properties entirely different from those of their constituent metals. By electrodeposition it is possible to co-deposit tin and nickel in the form of a compound containing approximately an equal number of tin and nickel atoms, and the alloy deposit obtained in this way possesses some properties superior in some respects to either of the constituent metals.

The tin-nickel alloy may be deposited direct on copper and copper-base alloys, but when the basis metal is steel, a copper under-coat is recommended. As the tin-nickel electrolyte attacks aluminium and zinc-base alloys, these materials cannot be plated directly but must first be protected by plating with a pore-free deposit of copper or alternative metal.

For most purposes a deposit thickness of 0·0005 in. will meet all requirements. For purely decorative purposes, where there is little wear or abrasion, a thickness of 0·0003 in. will ensure lasting resistance to tarnishing. These thicknesses apply to deposits on copper and copper-base alloys. In the case of steel, even when a copper undercoat is used, the thickness of the plate should never be less than 0·0005 in. and for some purposes a thickness of 0·001 in. may be needed.

INDUCTION HEATER

Radio Heaters, Limited, Wokingham, Berkshire, display among their exhibits their new Radyne C50 induction heater. We illustrate this machine in Fig. 8. It is designed for soldering, brazing and heat treatment, and is rated in accordance with B.S. 1799 : 1952, at 6 kW. The machine is tapped for operation from a 360, 400 or 440-volt 3-phase supply.

The main switch, the output meter and three tell-tale lamps are mounted at the front of the machine. The control buttons for the heat energy are contained in a separate unit which is connected to the right-hand side by a cable and socket plug. Alternative connections enable the heat to be controlled by either a foot-operated or limit switch. Process timers can also be incorporated. The variable control for the heat output is on top of the machine. The two output terminals can be seen in the centre of the front panel, and to these multi-turn or copper-plate heating inductors can be connected directly.

Heating can be produced at a high rate in both steel and in non-ferrous parts around which the coil is positioned. For parts which cannot be encompassed in the normal manner, ferro-magnetic heat intensifiers can be used to advantage.

The lower portion of the work table is cast in the form of a sink so that the cover can be removed. The heater is suitable for shrinking-on, " through " heating, and small hardening or melting jobs. A hardening jig can be mounted in the sink and the water quenching supply fed through an electrically-operated water valve.

A hand tool with a 7-ft. flexible lead may also be connected to the output terminals for work on articles which cannot be mounted on the table.

To maintain the heat output at maximum throughout the cycle, a motor-driven automatic power-control unit can be fitted. The machine is laid out in desk form with a 20-in. by 34-in. work table 42 in. above the ground, and the overall dimensions are height 56 in., breadth 34 in. and width 37 in.

COMPACTION MOULDING

One stage in the compaction moulding process now being used by the Ford Motor Company, Limited, Dagenham, for the production of rocker arms, is shown in Fig. 9, below. The materials used for the 20-tier mould are powdered phenolic resin and a fine grade of silica sand formed into an intimate mixture and containing approximately 3½ per cent. of resin. The example illustrated was displayed at the exhibition.

A metal corebox and top plate containing the patterns for rocker arm castings are heated to 400 deg. F. and sprayed with silicone emulsion. The box is automatically filled with a measured quantity of sand and resin mixture and levelled off. It then passes under a press, where the top-plate is fitted and squeezed into the mixture and the mould is conveyed through an oven at 1,100 deg. F., where the resin is cured in two minutes. The mould or core, then having acquired sufficient physical strength and being accurately moulded to the desired shape by the metal dies or patterns, is removed from the box.

With seven sets of dies in use, four operators can produce up to 120 cores per hour, each standard core carrying 14 rocker arm impressions. Core assembly is simplified by locators which ensure that the moulding contours are accurately matched when the cores are stacked one on the other. Complete assemblies of 20 standard cores with top and bottom runner cores can then be clamped together for pouring the molten metal. The following table gives some idea of the savings effected by this method when compared with the method previously in use.

General data	Old method (Green Sand)	New method (Compaction Mould)
No. of castings per tier	24	14
No. of tiers	1	20
Total castings per mould assembly	24	280
Fettled weight per casting	0·325 lb.	0·288 lb.
Poured weight per assembly ..	26 lb.	111 lb.
Casting yield from poured weight	30 per cent.	76 per cent.
Yield of good castings per 100 lb. poured	64	247

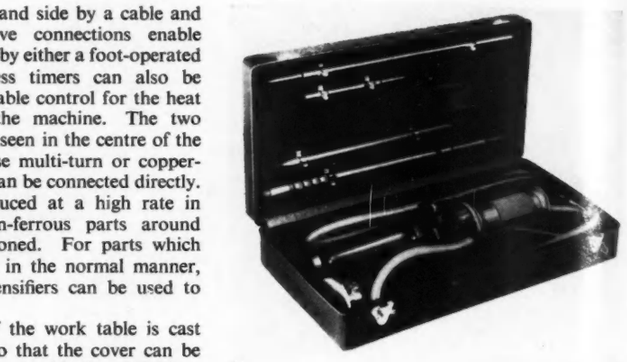


Fig. 10 An industrial stethoscope for the detection of fractures and other faults.

INDUSTRIAL STETHOSCOPE

The Murchie Trading Company, Limited, 11 King's-road, Sloane-square, London, S.W.3, were showing an industrial stethoscope for detecting noises between 20 and 7,000 cycles per second. This instrument, which we illustrated in Fig. 10, was developed in Belgium. Its prime application is the detection of faults in mechanisms such as internal-combustion engines and electric motors, together with the location of vehicle-body noise and escaping fluids.

The instrument consists of a solid metal body hollowed out at one end to form a resonance cavity. A disc mounted over the cavity acts as a valve and limits, or throttles, the audible noise which is picked up by a probe or sounding horn attached to the nose of the instrument. The disc can be manually adjusted by means of a screw which passes through the instrument. Alternatively, the probe can be replaced by a pilot

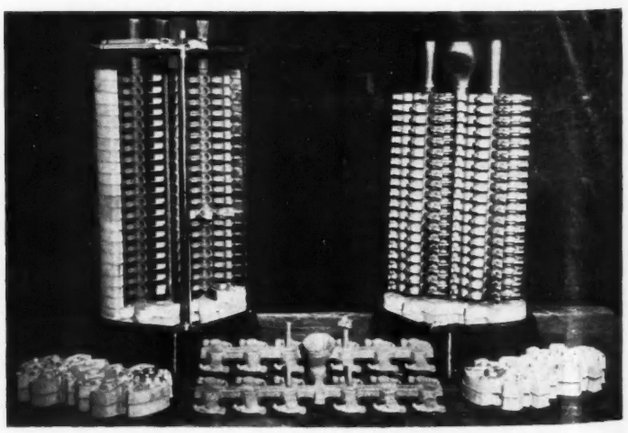


Fig. 9 In the foreground are rocker arms cast in simple moulds. Behind them, on the right, is the same type of rocker cast in large numbers by the compaction-moulding process. A section through a typical compaction mould is shown on the left.

tube or flat sounding disc, each device being used in conjunction with a particular type of investigation. Attached to the head of the main body are two flexible tubes connected to conventional stethoscope ear-pipes and plug.

MOBILE DEMONSTRATION UNIT

A mobile demonstration unit, which has just been completed and is the property of the Production Engineering Research Association, Melton Mowbray, Leicestershire, was also on display at the exhibition. It consists of a large Luton-type van and trailer. The van is built in the form of a cinema and lecture theatre, with seating accommodation for 24, and the trailer will be used for demonstrations and exhibitions.

This mobile unit will visit the industrial centres and assist firms in improving production by educational and other methods. Films and lectures illustrated by slides will show production techniques.

FORK-TRUCK LOAD-CAPACITY GAUGE

Lansing Bagnall, Limited, Basingstoke, Hampshire, manufacturers of fork-lift trucks, were showing one of their more recent innovations, a load-capacity gauge which can be attached to the mast of a fork-lift truck. It measures the moment of the load resting on the forks, the main factor affecting stability of the truck. A dial indicator shows the safe load range, and that the load is being carried in the correct position.

The moment applied to the forks is considered to be more important than the actual load because, in the standard fork truck without straddle arms, the whole of the load is carried outside the wheelbase of the vehicle.

The principle on which the indicator works has only been adopted since the recent introduction of a fixed mast and tilting carriage on the makers' fork trucks. The fundamental difference involved in the new truck design is that, when tilting the forks forwards and backwards in the normal way to clear the pallet when unloading, and to cradle it for added stability when travelling under load, the tilt is obtained by a small movement of the carriage only, instead of by a comparatively large movement of the whole mast structure. This results in an almost negligible increase in the moment of the load when the forks are tilted forward; on the other hand, with the normal fork truck, the overturning moment is considerably increased when the mast is tilted forward.

With the new design the forks are tilted by means of a pair of small hydraulic cylinders forming an integral part of the carriage. The force exerted by these cylinders to maintain the forks stationary is, of course, directly related to the applied moment and a pressure gauge tapped into the cylinders thus gives a true measure of the applied moment.

The overload indicator is supplemented by a cut-out which makes it impossible to lift loads exceeding the rated load capacity of the truck. This is also necessary because it would otherwise be possible to pick up some compact load, such as lead ingots, very close to the heel of the forks.

Coal-burning steam-turbine locomotive with electric drive for the Norfolk and Western Railway, U.S.A. Its impulse-type turbine develops 4,500 h.p. at 8,000 r.p.m.

AN AMERICAN STEAM-TURBINE LOCOMOTIVE

TOWARDS POWER-STATION EFFICIENCY

A coal-burning steam-turbine locomotive with electric drive which has been built for the Norfolk and Western Railway, U.S.A., is expected to have twice the thermal efficiency of the average coal-burning reciprocating locomotive and to be run at a fuel cost no more than, or better than, that of other forms of motive power. In design it is, perhaps, the nearest approach, in locomotive form, to power-station design. True, it does not include condensing equipment, but it has a water-tube boiler, a travelling grate (an innovation in locomotive practice), preheated air delivered to the grate under pressure, automatic regulation of the air and feed-water in relation to steam demand, and high and low water-level alarms.

It is believed to be the largest single-unit locomotive in the world. The impulse-type steam turbine develops 4,500 h.p. at 8,000 r.p.m. The locomotive is described as a joint enterprise of the Norfolk and Western Railway, the Baldwin-Lima-Hamilton Corporation, the Westinghouse Electric Corporation, and the Babcock and Wilcox Company.

As will be seen from the illustrations, there are two six-wheeled bogies at each end of the locomotive. The total weight, in working order, is 807,000 lb., and all of this weight is available for driving adhesion. The maximum tractive effort is 175,000 lb., and the rated continuous tractive effort is 144,000 lb. at 9 m.p.h. The maximum designed speed is 60 m.p.h. The water tender weighs 180,800 lb. empty and 365,000 lb. loaded, giving a total weight for the engine and tender in working order of 1,172,000 lb. (525 English tons). The coal and water capacities – 20 tons and 22,000 gallons respectively – are estimated to be sufficient for about 100 miles on ordinary freight service, which, on the Norfolk and Western Railway, includes some exceptionally heavy trains.

TRAVELLING GRATE

The Babcock and Wilcox boiler is a water-tube design with natural circulation. It supplies steam at 600 lb. per square inch and 900 deg. F. Coal is fired by a Standard mechanical stoker on to a travelling grate which, it is hoped, will ensure efficient combustion by maintaining a uniform fuel bed. Efficiency should also be enhanced by the large grate (even for such a large locomotive) which is understood to have been used, as the rate of combustion per square foot of grate area will be low. The preheated combustion air is supplied under pressure by an axial blower driven by a steam turbine. Though these features – of preheat and pressure – are not in themselves new, we are not aware of any recent combination of the two in locomotive design. Such an arrangement eliminates the conventional blast pipe and thus the loss of efficiency which would arise from back pressure on the main steam turbine.

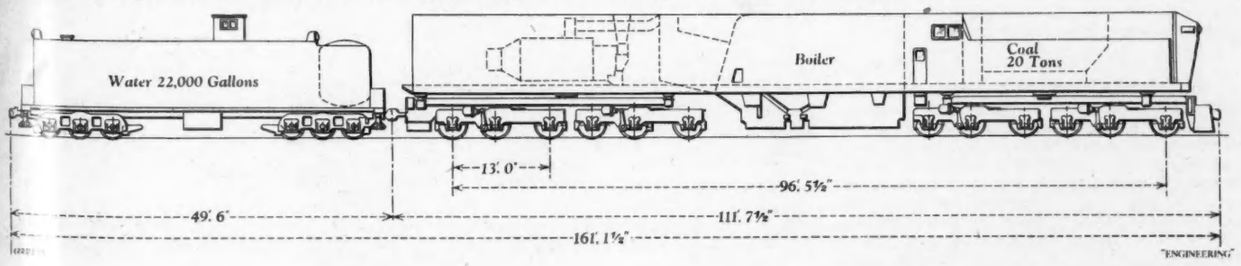
Feed-water is pumped from the tender through a zeolite softener. It is passed through a turbine oil cooler into an open-type de-aerating feed-water heater, and a booster pump delivers it to a main feed pump, which then passes it through an economiser to the boiler drum. Sodium sulphite is added automatically in the correct proportion. Continuous blow-down of the boiler is provided. In emergency, a high-pressure pump can deliver cold water directly from the tender to the boiler.

The Westinghouse turbine drives the main generator through single-reduction helical gears with a ratio of 8·9 to 1. Two armatures are carried on the generator shaft, and each is electrically connected to two parallel groups of three series-connected traction motors. The complete power plant is constructed as a single unit mounted at three points on the frame of the locomotive.

Bogies of a type which is already standard for Diesel-electric locomotives are used. The two at each end are spanned by a bolster which is loaded by a body centre-pin and by spring-plunger loading pads at the corners. The braking effort ranges from 35,000 lb. at 50 m.p.h. to 130,000 lb. at 14 m.p.h. The bogie wheels are 3 ft. 6 in. in diameter.

The master controller has a throttle and reverse lever. The throttle, with 12 notches and "on" and "off" positions, actuates the turbine speed changer pneumatically and controls the main-generator excitation.

Weekly Survey in this issue includes a note on the Norfolk and Western steam-turbine locomotive.



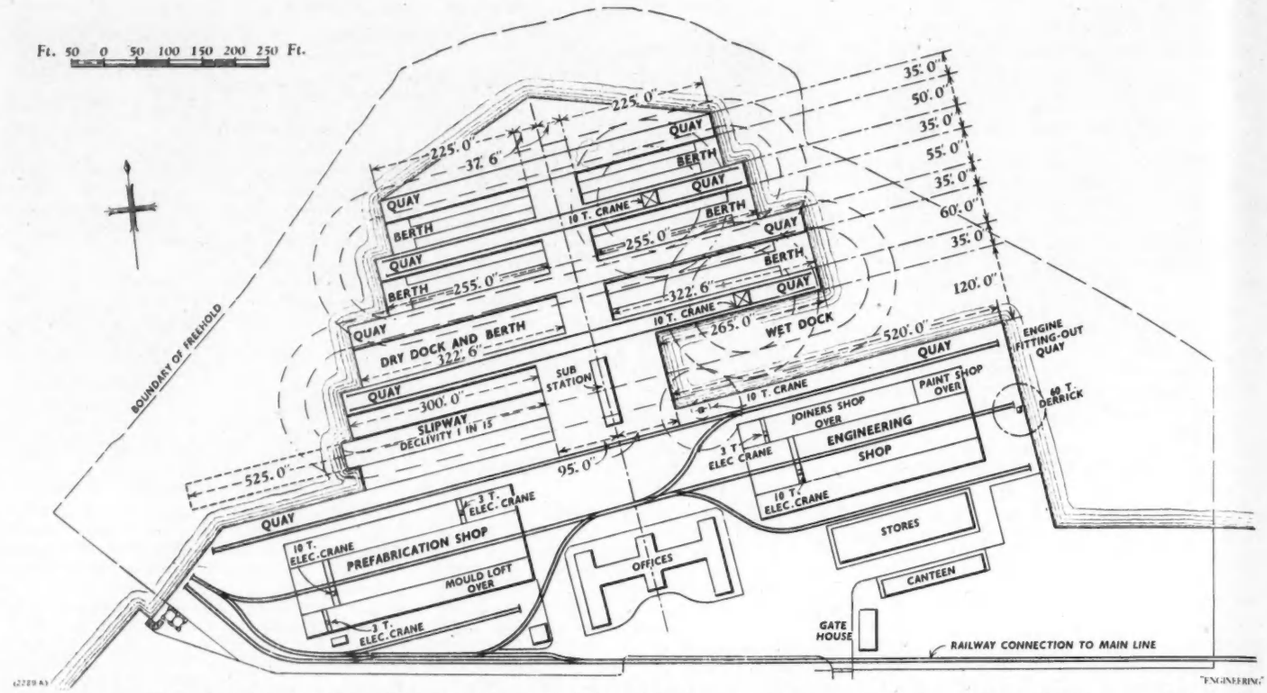


Fig. 1 The new shipyard for Brooke Marine, Limited, at Lowestoft, is being laid down on a promontary and this, combined with the symmetrical layout, will allow vessels to be launched both upstream and downstream instead of across stream. Rail tracks serve the stacking yard, main workshops and quayside; travelling cranes serve the berths.

DESIGN OF A NEW SHIPYARD

PREFABRICATION IN SHIPBUILDING

A new shipyard for the construction of between 12 and 18 vessels per annum, ranging in overall lengths of between 200 ft. and 280 ft., is being laid down in the South Shipyard of Brooke Marine, Limited, Lake Lothing, Lowestoft. The yard has been planned for line-flow production, the steel being brought into the stacking yard, through the prefabricating shop (where units of up to 10 tons will be put together), and out to the construction berths; similarly, the engineering supplies will be dealt with in a like manner, the engines being constructed in the shops before being transferred as large assemblies for installation at the fitting-out quay.

The feature of the civil-engineering work now being undertaken is the extensive adoption of pre-cast concrete members, using both ordinary bar reinforcement and prestressed cables. Such members have been used throughout the yard for coping stones, conduit covers and paving slabs, and all the buildings, both principal and auxiliary, are almost entirely constructed of prefabricated concrete units. In particular, the two principle buildings, the prefabrication shop and the engine shop, are likely to be the largest framed structures ever to be built of this type of member; the two buildings, identical in dimension and layout, are the size of a fairly large power station and, until recent years, would have been constructed of steel or, alternatively, concrete cast *in situ*, when considerable quantities of expensive shuttering would have been required.

DEVELOPMENT OF THE PROJECT

The development of these new yards was based on the acquisition of the shipbuilding company, Brooke Marine, Limited, by the Dowsett group of companies at the beginning of the last war. The facilities then taken over consisted of what is now only part of the North Yard (located on the opposite side of the waterway) and that yard was extended to the limits during hostilities. The freehold area of the new South Yard was bought during the war and additional lands acquired recently so that the total site on the south bank now covers an area of about 35 acres. This ground was mostly tidal swamp (overlying a coarse sand) and the whole of it was liable to flooding on the spring tides except for a small section which was developed soon after its acquisition. This previous development consisted of some slipways and steel sheds built about ten years ago, but their sorry state, in spite of regular painting, has been a significant factor in causing the new buildings to be built of concrete.

With the end of the war, and the cessation of Admiralty orders, Brooke Marine had to re-establish their yards for commercial construction and, about three years ago, the first tentative plans for the new South Yard were drawn up. These plans had been completed in detail when the company were successful in obtaining a substantial contract during the recent Anglo-Russian trade talks. The award of the contract has meant that the completion date for the yards has been brought forward as far as possible and, though certain preliminary work was actually carried out in the latter months of 1953, it was not until January of this year that construction was fully under way.

The contractors for the work are, of course, the Dowsett group of companies, both the design and site work (as well as the supply of most of the materials, particularly the manufacture and

Fig. 2 One of the erection berths constructed behind the temporary flood bank which has still to be breached. Floating caissons will be used to close the berths and the dry dock when ships are under construction.

erection of the precast concrete) being undertaken by subsidiaries of the group. Detailed design of the berths and quays and the general construction work at site is in the hands of Dowsett Engineering Construction, Limited (Midland Area) and the pre-cast and prestressed concrete has been manufactured by Dow-Mac (Products), Limited, Tallington, near Stamford, Lincolnshire.

As has already been stated, the yard has been planned to construct vessels up to the capacity of the berths by the shop fabrication of pieces which are then to be conveyed to the slipways. For the ready supply of materials, a direct link has been made with the main railway at Lowestoft and direct access is also available by road. The site is located on the south side of Lake Lothing, with direct access to the sea through Lowestoft Inner Harbour for vessels of up to 50-ft. beam and 18-ft. draught. The layout, shown in the plan Fig. 1, is planned symmetrically about a centre line running approximately north and south through the vertex of a promontory in the shore line. Ships will therefore be launched both upstream and downstream, and not, as is customary, across the stream towards the opposite bank.

With prefabrication of the ships as the basis of construction, it was decided that a 10-ton unit should be worked as far as is possible, and crane capacity to this figure (with a factor of safety for overloads) has been provided for the whole yard. The engines for all the vessels are to be fitted at the yard and a 60/100-ton crane is to be installed at the engine quay for this purpose.

In order to cut down general handling of materials, a shunting locomotive crane has been obtained, and as may be seen from the plan, all rail trucks can be passed through both the major shops as well as to sidings alongside the main stores, the steel-stacking yard, the slipway and the wet-dock area. It was decided not to extend the rail tracks to the building berths themselves – in any case, track alignment would have been difficult and the turnouts very tight – and greater flexibility will be obtained by the proposed use of 10-ton and 20-ton rubber-tyred trailers, pulled by tractors with pneumatic wheels. Two rail-mounted Monotower cranes serve the berths, wet dock and slipway.

So that the yard shall remain clean, tidy and safe for working, the amount of temporary electrical leads and air lines that will be required has been cut to a minimum by the construction of a central sub-station and a central compressor house, with the services laid in ducts to numerous tapping points in the berths and in the shops. Likewise, to prevent scrap from being dumped indiscriminately, all spare areas not required for production have been arranged as grass or flower beds.

CONSTRUCTION FACILITIES

Construction facilities at the new yard comprise eight berths or docks and the engine quay, their relative location being shown on the plan. To exclude water from the berths and dry dock while construction is under way, floating caisson gates will be provided. The floors of the berths have been slabbed with reinforced concrete supported by piles below the keel line and with additional piles below the cill for carrying the load at the moment of launching. A berth is shown in Fig. 2, opposite.

The two short berths at the end of the promontary are 225 ft. long by 50 ft. wide and are designed for building and launching vessels up to 200 ft. in length; the depth of water at the end of the launchway will be 10 ft. 3 in. at H.W.O.S.T., increasing to 20 ft. at the cill. The next pair of berths, 255 ft. long by 55 ft. wide, are for vessels up to 230 ft. in length, the depth of water at H.W.O.S.T. increasing from 12 ft. 3 in. at the end of the launchway to 22 ft. On the east side, there is a single berth for vessels up to 280 ft., the berth being 322 ft. by 60 ft. and the water depths, 13 ft. 6 in. to 22 ft. 6 in. Opposite this berth and on the west side is the combined berth and dry dock which will accommodate 300-ft. vessels.

At the landward end of the site are the wet dock and the slipway. The wet dock has 860 ft. of quay wall available for fitting out and will float vessels with a draught of 16 ft. at all states of the tide. It has been dredged to a general level of 22 ft. 6 in. and, for 280 ft., to 25 ft. 6 in. below H.W.O.S.T. The bottom will be left soft so that, in the event of exceptionally low water, vessels can settle with safety. On the opposite side of the site, the slipway has a length of 520 ft. rising from 22 ft. 6 in. below H.W.O.S.T.; the width is 40 ft. with side-slipping facilities over a length of 260 ft. at the inner end.

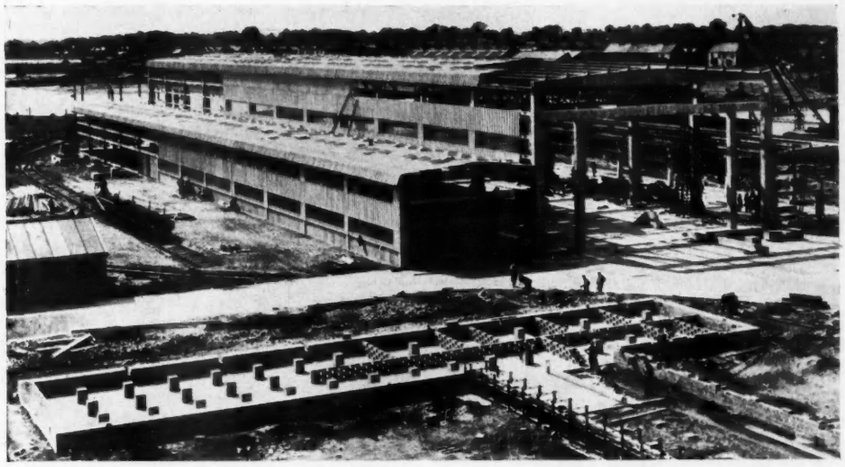


Fig. 3 The prefabricating shop, 360 ft. long by 150 ft. wide, with asbestos and Perspex-sheet cladding over a pre-cast concrete frame.

The two main buildings in the new yard are the prefabricating shop and the engineering shop. Each of these buildings is 360 ft. long by 150 ft. wide with a central bay 75 ft. wide and two side bays 37 ft. 6 in. wide. The clear height to the soffit of the main roof beams is 41 ft. 6 in. and of the side bays, 20 ft. One of the side bays to each of the shops has an intermediate floor, used to provide a mould loft in the prefabrication shop, and a joiners and paint shop in the other building. The nearly completed prefabricating shop is shown in Fig. 3.

The prefabricating shop is to be equipped for the fabrication of plates and sections necessary to form units of ships' structures, weighing up to 10 tons, and will be able to handle up to 300 tons of plate and bar per month.

The annexe on the north side will be used for the fabrication of the plates and consists of a marking-out bay and accommodation for punching, rolling as well as plate bending and folding machines, together with radial-drilling machines mounted on tracks. A 3-ton overhead crane is available for the full length of this annexe. Automatic submerged-arc welding machines will be laid down in the centre bay, which is served by a 10-ton overhead crane, and welding skids will be provided on which the prefabricated units will be built up before transport to the berths.

In the engineering shop, the southern annexe is equipped with woodworking machinery for handling all shipwrights' and joiners' timber. The north annexe has accommodation for a fitters' shop, electricians, plumbers and coppersmiths, each shop being equipped with the appropriate plant. Every machine tool is driven by a separate electric motor and, as in the prefabrication shop, the main bay is served by a 10-ton electric overhead crane. Machinery will be installed for the production of tail shafts and covered accommodation will enable both main and auxiliary machinery to be built.

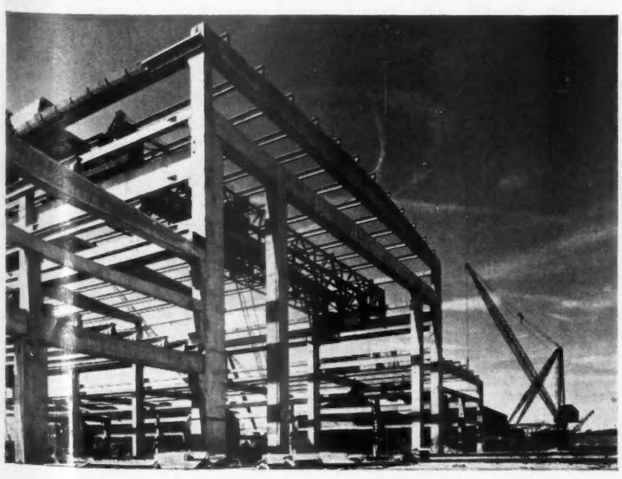


Fig. 4 The framework of the prefabricating shop and the engine shop consists of large pre-cast concrete members. The columns are of plain reinforced-concrete, with haunches to receive stringer beams; the beams and purlins are prestressed.

AUXILIARY BUILDINGS AND SERVICES

Auxiliary buildings include the main stores, the compressor house and substation, canteens and kitchens, gatehouse, inspectors' offices and the main office block. Each of these buildings is built entirely of pre-cast concrete members made at the contractor's works at Tallington.

Services in the yard include the cranes, electricity, compressed air, fresh water and gas. Apart from the cranes already mentioned (the Monotowers serving the berths and the overhead cranes in the shops) there will also be: a 5-ton rail-mounted Diesel shunting crane in the sidings; a 60-ton derrick with a 40-ft. radius on the engine-fitting quay; and a 20-ton Coles travelling crane for general work.

Electricity is brought into the yard through a

new substation which will have an eventual capacity of 1,500 kVA; welding transformers of 350-ampere capacity for either 6 or 12 operators have been installed for each of the berths, quays, and main shops. Four 520-cub. ft. per minute compressor sets, electrically-driven, have been installed to meet initial requirements, with provision for increasing the capacity by 50 per cent.

All the service pipes are laid in pre-cast concrete ducts; at the quays, tapping points have been made in the vertical faces of the coping stones so that duct covers will only have to be raised for major maintenance works or for new installations. This arrangement will also ensure the minimum of trailing cables, so leaving uninterrupted space for the passage of mobile cranes and for other operations.

CIVIL ENGINEERING AT SITE

The principal civil-engineering work at the site has included: the mass excavation for the berths and docks, and the use of the spoil as fill; the driving of 1,600 tons of sheet piling in the quay walls; driving prestressed-concrete bearing piles under keelways, crane tracks, foundations, etc.; preparation of foundations for the main workshops and erection of the main frames; laying of roads, service ducts and the railways. The rapid progress made, with a labour force that has at no time exceeded 180 men, has been made possible by the extensive use of prestressed and pre-cast concrete members and the high proportion of cranes available on the site.

Steel-sheet piling for the wet dock consisted of 45 ft. and 41 ft. lengths of No. 3 Frodingham and B.S.P. piles which were driven to an average set of 38 ft. A variety of plant was employed and piling proceeded in two 12-hour shifts (11 shifts per week); between the last week in November and April 1954, 1100 tons of sheet piling were driven. The concrete piles for the Monotower tracks, the launchways, supports to the building quays and main workshops consisted of 12-in. by 12-in. prestressed-concrete piles, 25 ft., 30 ft. or 35 ft. in length. These have been driven by either a 24 RB or 37 RB, using either a timber frame or false leaders suspended from the jib. Bakelite dollies have been found to be extremely effective, giving less trouble and a longer life than ordinary timber.

The concreting of all the roads and floors has been done with three 14/10 Winget Weigh-batchers, the concrete gangs working single 12-hour shifts and using Dobbin barrows for distribution.

The choice of pre-cast concrete members for the main workshops was based primarily on the poor record of steel structures in the locality, it being believed that the concrete will weather and will require only a small amount of maintenance.

Throughout, the construction is of reinforced-concrete columns with prestressed concrete stringers and cross beams; felt pads have been used as bedding for the main roof beams where they bear on to the column tops. The main design is based on the strength of the columns to resist the lateral wind loading and all vertical loading; the foundations have been designed to resist the overturning moments, and ground-bearing pressures have been limited to 2 tons per square foot, bearer piles being used to increase the resistance where necessary. The main columns weigh 16 tons each and are suitably shaped to receive the crane-gantry rail bearers and the roof beams, as is well shown in Fig. 4, on the previous page. The roof beams, fully prestressed with 100 wires of 0·2 in. diameter, are 4 ft. deep at the centre and 1 ft. 9 in. at the end with a constant width of 20 in.; each beam weighs 15 tons.

Roof cladding consists of "Universal" asbestos-cement reinforced troughing sheets with roof lights to augment the lighting from the Perspex glazing in the side walls. Side cladding, above the 9-ft. dado line, is of asbestos-cement sheets and the Perspex glazing; below the dado, to avoid damage, the walls are pre-cast prestressed-concrete slabs, 3 in. thick.

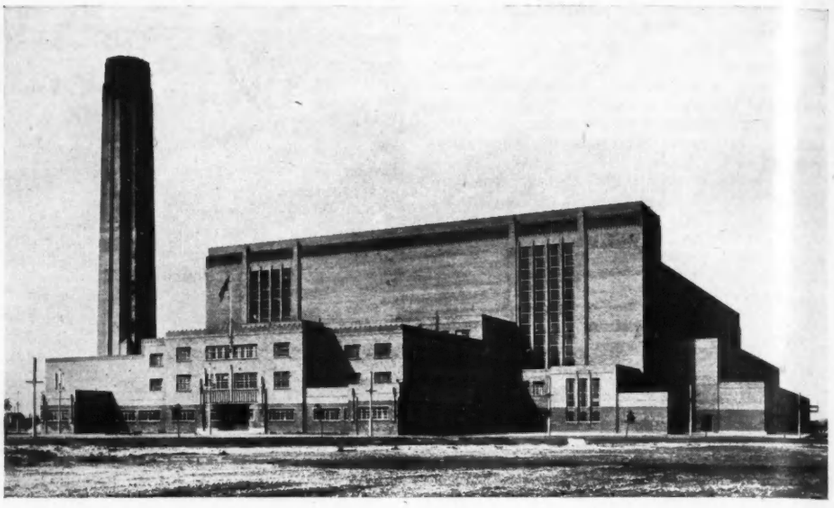


Fig. 1 Exterior of 128-MW generating station at Rye House, Hertfordshire, the buildings of which have been designed by Sir Giles Gilbert Scott.

128-MW POWER STATION AT RYE HOUSE

UNIT SYSTEM WITH PULVERISED-FUEL FIRING

The 128-MW generating station at Rye House, near Hoddesdon, in the Eastern Division of the British Electricity Authority, was officially opened by the Lord Lieutenant of Hertfordshire (the Hon. David Bowes-Lyon) on Thursday, July 22. Before the war it was agreed that a new generating station in the then Northmet Power Company's area was necessary and of the four sites examined that at Rye House was considered to be most suitable. This site has an area of about 100 acres with a frontage of 3,400 ft. to the River Lea Navigation. It also adjoins the main Cambridge line of the Eastern Region of British Railways. Owing to the war the construction of the station, which is operated on the unit principle, was deferred until 1947. Up to date, four machines with an aggregate capacity of 128 MW have been installed, but the ultimate capacity, which will be made up of six 32-MW sets, will be 192 MW.

DETAILS OF LAYOUT

The buildings, which have been designed by Sir Giles Gilbert Scott, O.M., are illustrated in Fig. 1. They comprise a boiler house with an eventual length of 420 ft., a width of 100 ft. and a height of 100 ft. The turbine-house and mechanical annexe have a combined width of 150 ft. The general layout is such that the turbo-alternators are arranged transversely with the coal bunkers and mechanical annexe between the boiler house and turbine room, an illustration of which is given in Fig. 2. The electrostatic precipitators are installed outside the boiler house. The induced-draught fans are also out of doors at ground level and are partially protected by the precipitators and the main flue leading to the chimney. The main civil engineering contractors were Walter Lawrence and Son, Limited, 31 Sun-street, London, E.C.2; the steelwork having been made by Dawnays, Limited, Battersea, London, S.W.1. The railway sidings were constructed by Thomas Summerson and Sons, Limited, Darlington.

Coal for the station is brought by railway wagons into reception sidings from the East Midlands coalfields and is handled thence by a locomotive constructed by Robert Stephenson and Hawthorns, Limited, Darlington, to two tipplers. These tipplers, which were constructed by Mitchell Engineering, Limited, Bedford-square, London, W.C.1, are capable of dealing with ten 20-ton wagons per hour and are fitted with dust-removal plant manufactured by the Sturtevant Engineering Company, Limited, Cannon-street, London, E.C.4. Coal is delivered from the tippler building by underground conveyors to a gravity-bucket conveyor, which raises it to conveyors in the boiler house, a travelling tripper being installed to facilitate stocking in the bunkers. It can also be delivered and reclaimed from a store by a Beaumont drag scraper plant with a capacity of 200 tons per hour and an average haul of 220 ft. The initial pile on which the scraper works is formed by a radial belt conveyor which swivels through an angle of about 120 deg. The main contractors for this portion of the plant were International Combustion, Limited, 19 Woburn-place, London, W.C.1.

STEAM-RAISING PLANT

The present steam-raising plant consists of four series high-head boilers with Bailey water-cooled combustion chambers. They were manufactured by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, and each has a maximum continuous output of 350,000 lb. of steam per hour at a pressure of 650 lb. per square inch and a temperature of 875 deg. F. They are fired with pulverised fuel from four Babcock and Wilcox mills, the upper sections of which contain a classifier, so that the coarse particles are returned for further treatment. Each mill is fed by a table of the slow-speed rotating-disc type, which is designed to give a regular supply over the full range of operation.

The superheater is of the single-pass type, the economiser being of the integral steaming pattern and arranged in two sections. These sections are installed back-to-back inside the boiler casing with water in counter-flow to the gases. Both superheaters and economisers were manufactured by Babcock and Wilcox, Limited. Two Howden-Ljungstrom regenerative air heaters

each having a heating surface of 55,900 sq. ft., are provided on each boiler. The boilers are fitted with Babcock single-nozzle retractable soot blowers and the air heaters with fixed-jet blowers. All these blowers can be operated either automatically on sequence control or manually.

There are two forced-draught and two induced-draught fans on each boiler, all of which were manufactured by James Howden and Company, Limited, 195 Scotland-street, Glasgow, C5. The former are of the single-inlet Turbovane type and the latter of double-inlet design. All are provided with vane control equipment, which is operated on the Lockheed hydraulic system, and are directly coupled to motors manufactured by Lancashire Dynamo and Crypto Limited, Manchester. The primary-air fans are of the single-inlet centrifugal type.

ASH AND DUST HANDLING PLANT

The ash and dust handling plant, which was manufactured by B.V.C. Industrial Constructions, Limited, Leatherhead, Surrey, is of the hydrojet type and is designed to discharge into a sluiceway with a capacity of 40 tons per hour. Water is supplied to this sluiceway by single-stage centrifugal Gwynne pumps, each of which is capable of passing 1,700 gallons of water per minute against a head of 275 ft. The ash is discharged from the sluiceway through an electrically-driven crusher into a sump whence it is pumped into an elevated drainage bunker. This bunker is in two halves, each of which has a capacity of 60 tons, and from it the drained ash is delivered by conveyors either into railway wagons or lorries.

The dust from the electrostatic precipitators, which were manufactured by Lodge-Cottrell, Limited, George-street Parade, Birmingham 3, is removed by hydraulic ejectors and is discharged into a sluiceway whence it is delivered to the ash sump. It is removed from this sump by connecting a single-stage centrifugal slurry pump in series with the ash pump and is deposited in neighbouring worked-out ballast pits.

TURBO-ALTERNATORS

The four turbo-alternators now in operation were constructed by Richardsons, Westgarth (Hartlepool), Limited, Hartlepool, to the design of Brown Boveri, Limited. The turbines are three-cylinder, simple tandem, impulse-reaction machines, the high-pressure and intermediate cylinders being constructed of molybdenum cast steel, the low-pressure cylinder being close-grained cast iron. The high-pressure rotor has one row of impulse blades and 22 rows of reaction blades and there are 18 rows of reaction blading in the intermediate-pressure cylinder. The low-pressure cylinder has two groups of five rows of reaction blading.

The steam conditions at the intermediate and low-pressure inlets are 190 lb. per square inch and 610 deg. F. and 0·3 lb. per square inch and 212 deg. F., respectively. The designed steam consumption at full load was 9·04 lb. per kilowatt-hour with a heat consumption rate of 10,060 B.Th.U. per kilowatt-hour.

The turbines are directly coupled to main and auxiliary alternators, which were manufactured by C. A. Parsons and Company, Limited, Newcastle-on-Tyne, 6. The main alternators have a rating of 30 MW at a speed of 3,000 r.p.m. and supply three-phase current at 33 kV and 50 cycles. The auxiliary alternators have an output of 2,000 kW at 3·3 kV and 50 cycles.

Cooling is on the closed-circuit principle, the air being circulated by duplicate fans, each of which is capable of delivering 70,000 cub. ft. of air per minute against a discharge pressure of 16 in. water gauge. The ventilating system is provided with an alarm which operates if the air exceeds a certain temperature.

CONDENSING AND FEED-HEATING PLANT

Steam is discharged into twin-shell two-pass condensers. These condensers, which were manufactured by Richardsons, Westgarth (Hartlepool), Limited, have a total cooling surface of 40,000 sq. ft. and are designed to give a vacuum of 28·8 in. The quantity of water required for this purpose is 23,500 gallons per minute at an inlet temperature of 65 deg. F. In the event of the condenser not being able to maintain a satisfactorily low back pressure a relay operated device is incorporated in the turbine control system which automatically reduces the load.

Sufficient cooling water is obtainable from the River Lea to supply the requirements of one set. This supply is augmented by three reinforced-concrete cooling towers which were constructed by the Davenport Engineering Company, Limited, Bradford, and each being capable of dealing with 1·35 million gallons of water per hour. Each tower is supplied by two pumps of Mather and Platt manufacture, which draw water from a culvert common to all the condensers. The towers discharge through their ponds to a common inlet culvert into which the river water is also drawn. All three towers are therefore in parallel and can be used singly or in combination to suit which ever machines are running. The contractors for the circulating-water system and culverts were William Press and Son, Limited, 22 Queen Anne's Gate, London, S.W.1, and J. L. Kier and Company, Limited, 7 Lygon-place, London, S.W.1.

As regards the feed-heating system air is extracted from the condensate by three-stage ejectors with a dry air capacity of 113 lb. per hour. These ejectors are jet-operated by live steam, which is condensed in the casing through which the condensate is pumped. The two extraction pumps on each condenser, are of the vertical-spindle Pervac type and have an output of 600 gallons per minute. They were manufactured by Drysdale and Company, Limited, Yoker, Glasgow, W.4, and are electrically driven. Each is capable of dealing with all the condensate at the maximum continuous rating as well as with the cascaded and other drains.

The condensate is discharged into a four-stage feed heating and de-aerating system comprising a combined low-pressure heater and drain cooler, a low-level de-aerator, feed pumps and two stages of high-pressure heaters. The low-pressure heater and drain cooler, which was manufactured by Richardsons, Westgarth (Hartlepool), Limited, is of the six-pass horizontal type with a surface of 1,000 sq. ft. The de-aerator, which was supplied by the same firm, is of the flash type with direct-contact heating and a horizontal water storage tank. Its heating surface is 600 sq. ft. and it is designed for a flow of about 340,000 lb. per hour.

EVAPORATORS

The evaporators, which were manufactured by Aiton and Company, Limited, Derby, are of the vertical straight-tube type and are operated with steam bled from the turbine. Alternatively, when the turbine is on no-load or shut down, the vapour-compression method employing live steam can be employed. The units are fitted with raw water pre-heaters, which are capable of raising the temperature of the raw water nearly to saturation temperature.

The feed pumps, which have been manufactured by G. and J. Weir, Limited, Cathcart, Glasgow, S.4, are of the ten-stage horizontal centrifugal type and each is capable of delivering 193,000 lb. of water per hour against a discharge pressure of 940 lb. per square inch. There are three electrically-driven pumps to each set, while a stand-by steam-driven pump is provided for the first two boilers. The two high-pressure heaters are of the Richardsons, Westgarth vertical-pass U-tube type.

ELECTRICAL EQUIPMENT

The main alternators are directly connected to the bus-bars of the switchgear, which was manufactured by the British Thomson-Houston Company, Limited, Rugby. This switchgear has a rupturing capacity of 1,000 MVA and is arranged in two groups of double bus-bar form with two oil circuit-breakers in each circuit. A supply to the grid is stepped up in four 45-MVA, 32/132-kV transformers which were manufactured by the Fuller Electrical and Manufacturing Company, Limited, Walthamstow, London, E.17, and also act as reactor couplings between the two groups of switchgear.

The works auxiliaries are supplied either from the house-service alternators or from the main bus-bars through four Fuller 3-MVA, 33/3-kV transformers. The low-tension sides of these transformers are connected to double bus-bars.

The control room, which is situated in the administration block, is equipped with semi-miniature panels each of which has its own alarm annunciator. Running control is effected from a central desk and synchronising at the panels by trolley-mounted equipment. The turbine and boiler-house telegraph transmitters are also mounted on the control desk.

The Controller of the Eastern Division, British Electricity Authority, is Mr. W. N. C. Clinch, to whom we are indebted for the information contained in this article.

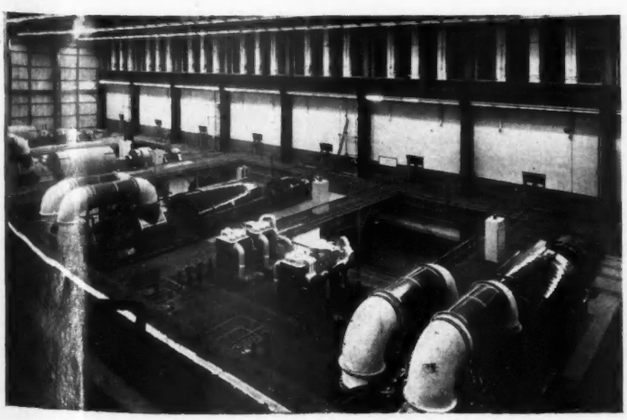


Fig. 2 Interior of turbine room at Rye House power station, showing transverse arrangement of plant.

IGNITRON CONTACTORS FOR LARGE CURRENTS

ELECTRONIC SWITCH PROVIDES WELD-HEAT CONTROL

The control of the large currents which are frequently necessary in resistance welding, especially where a high rate of production is required, can advantageously be effected by ignitrons, as they have no moving parts, are silent in operation, and require no maintenance. In addition, they enable the time during which the welding circuit is closed to be finely adjusted and thus provide what is known as synchronous or " weld-heat " control.

To obtain the full benefits of this system of control, however, the " start " contacts of the pair of ignitrons normally used must not only close during the appropriate positive or negative half cycle, but at a definite point in those half cycles. To enable this to be done Bates and Bates, Limited, 73 Ashville-avenue, Birmingham, 34, have designed an electronically-operated switch, which is illustrated in Fig. 1.

The principle on which this switch operates is shown in Fig. 2. In this diagram, *a* and *b* are thyratrons, which are connected in reverse parallel. The grid of each of these thyratrons is maintained negative by bias voltages, which are shown diagrammatically as batteries *c* and *d*. Thus no current passes, even when an alternating voltage is applied across the thyratrons. Highly peaked pulses from special transformers *e* and *f* are also applied to the grids; but the maximum voltage of these pulses is deliberately maintained at a value below the negative voltage from the batteries.

FIRING THYRATRONS

If the negative bias on the grid of thyratron *a* is reduced to a value slightly less than that of the voltage from the peaking transformer *e*, the first pulse from this transformer will fire the thyratron and current will flow from line 1 through the load to line 2. This current will be cut off when the voltage applied to thyratron *a* reverses. Thyratron *b* will, however, remain non-conducting as the negative voltage across its grid has not been altered. Current will therefore only flow through the load during a single half cycle. Thyratron *a* will be fired by the next pulse from the peaking transformer, provided its negative bias has not been increased.

Thyratron *b* is also fired by reducing the negative bias of its grid. This is done by supplying a feed-back pulse from the load, as shown in Fig. 2, and can, of course, only take place after a current has passed through the load, that is, after thyratron *a* has fired. The actual point on the alternating-current wave at which each thyratron fires is determined by the peaks of the pulses. The duration of the current through the load during each half cycle can therefore be altered by varying the phase relationships of these peaks to the supply voltage.

This is illustrated in Fig. 3 (*a*), which shows the currents Iv_1 and Iv_2 through each thyratron when applied to a highly inductive load such as a transformer. In this particular case the firing of each thyratron is arranged to occur at a point very close to the angle at which the current normally lags behind the voltage. Under these conditions the currents Iv_1 through thyratron *a* and Iv_2 through thyratron *b* very nearly form a continuous sine wave.

ADJUSTING FIRING POINT

If the firing point of the thyratrons is delayed, current will pass through each for less than half a cycle. As shown in Fig. 3 (*b*) the currents Iv_1 and Iv_2 are then broken into separate pulses each of which resembles half a sine wave, but lasts for less than half a cycle. The average value of the load current is thus reduced. In other words, the root-mean-square value of the current, which determines the heat in the weld, can be varied by adjusting the firing point of the thyratrons.

A diagram of the adaptor, in which these principles are utilised, is given in Fig. 4. Thyratron *a* determines the firing point of ignitron *c* in the way already described, and thyratron *b* similarly controls the firing point of ignitron *d*. Thyratron *b*, and thus ignitron *d*, cannot fire until thyratron *a* has fired. Once thyratron *a* has fired, however, the feed-back pulse from it enables thyratron *d* to fire during the next half cycle.

The phase angles of the pulses from the peaking transformers, which determine the firing of the thyratrons, can be altered with respect to the supply voltage by using a combination of a variable resistance and a condenser. The load current can also be smoothly adjusted by a rheostat which can, if desired, be remotely controlled.

UNIFORMITY OF WELDS

Full synchronous control can be effected by connecting the adaptor across the " start " terminals of the ignitron contactor and line 2. The welding transformer will now be supplied with current at the normal angle of lag or, if desired, a little behind this angle. Transient currents are thus eliminated owing to the fact that the point when the current begins to flow in each half cycle is precisely determined. This " leader-follower " arrangement of the adaptor also ensures that a negative pulse will always follow a positive pulse. A weld cannot therefore be made with a pulse of the same polarity as that of the previous weld.

STEPLESSLY-VARIABLE WELD HEAT

A further advantage of the elimination of transient currents is that each weld is similar to the previous one, so that constant settings can be used and heavy-current rushes, which cause dips in the supply voltage, are prevented. The control of the weld heat is smooth and infinitely variable, even when the current is flowing, although arrangements can be made for altering the welding current in steps or at adjustable pre-determined rates. Within its mechanical and electrical range any welding machine fitted with such an ignitron-control adaptor can be used to deal with all types of ferrous and non-ferrous metals and alloys.

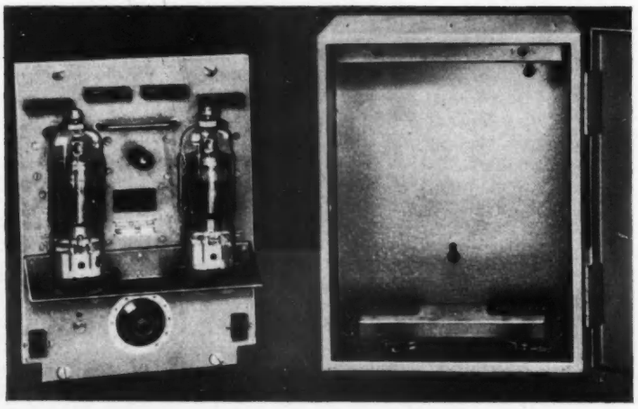


Fig. 1 Electronically operated switch for controlling the " weld-heat " currents in resistance welding.

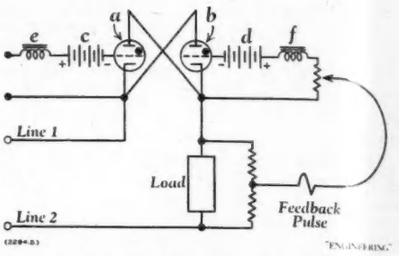


Fig. 2 The successive firing of two thyratrons provides the basis for the electronic switch; the operating principle is illustrated here.

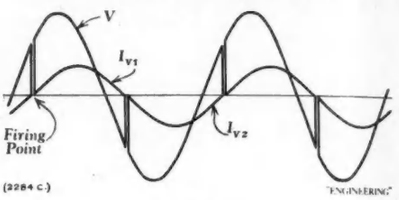


Fig. 3a

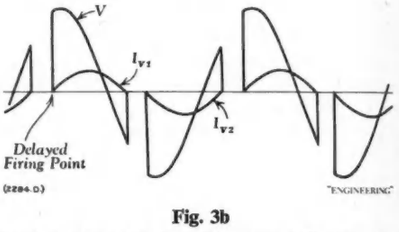


Fig. 3b

Figs. 3 (a) and 3 (b) Diagrams indicating the method by which the duration of the current through the weld can be altered.

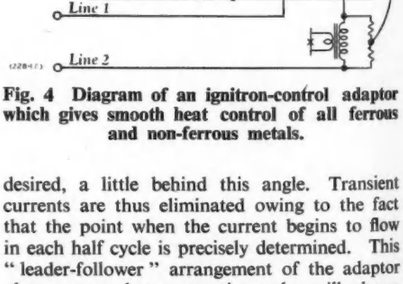


Fig. 4 Diagram of an ignitron-control adaptor which gives smooth heat control of all ferrous and non-ferrous metals.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. An asterisk(*) indicates events appearing in the list for the first time. Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *June 25, page 831. Organisers are invited to send to the Editor particulars of forthcoming events.*

RIDINGS INTERNATIONAL FAIR.—Sat., July 31, to Sat., Aug. 14, at Harrogate. Organised by Regional Exhibitions, Ltd., Salfords, Surrey. Tel. Horley 64.

DANISH INDUSTRIES FAIR.—Thurs., Aug. 5, to Sun., Aug. 15, at Fredericia, Denmark. Organised by Dansk Kobestaevne Fredericia, Jutland, Denmark.

*ROYAL LANCASHIRE AGRICULTURAL SHOW.—Tues., Aug. 10, to Fri., Aug. 13, at Stanley Park, Blackpool. Organised by the Royal Lancashire Agricultural Society, 12 Winckley-square, Preston. Tel. Preston 3666.

*SYDNEY MOTOR SHOW.—Fri., Aug. 13, to Sat., Aug. 21, at the Showground, Sydney. Organised by the Chamber of Automotive Industries of New South Wales, 75 William-street, Sydney.

INTERNATIONAL MODEL ENGINEER EXHIBITION.—Wed., Aug. 18, to Sat., Aug. 28, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Apply to Mr. G. Withers, 19 and 20 Noel-street, London, W.1. Tel. GERrard 8811.

NATIONAL RADIO AND TELEVISION EXHIBITION (21ST).—Wed., Aug. 25, to Sat., Sept. 4, at Earl's Court, London, S.W.5. Apply to the Radio Industry Council, 59 Russell-square, London, W.1. Tel. MUSeum 6901.

*PACIFIC NATIONAL EXHIBITION.—Wed., Aug. 25, to Mon., Sept. 6, at Vancouver. Manager: Mr. V. Ben Williams, Exhibition Park, Vancouver, British Columbia.

*CANADIAN NATIONAL EXHIBITION.—Fri., Aug. 27. to Sat., Sept. 11, at Toronto. *Agent:* Mr. G. H. Ward, 3 Lower Regent-street, London, S.W.1. Tel. WHItehall 2794.

ST. ERIK'S INTERNATIONAL FAIR.—Sat., Aug. 28, to Sun., Sept., 12, at Stockholm. *Agents:* Thirza West Publicity Ltd., 141 New Bond-street, London, W.1. Tel. MAYfair 3701.

SYMPOSIUM ON FLAMES AND COMBUSTION (FIFTH).—Mon., Aug. 30, to Fri., Sept. 3, at the University, Pittsburgh. Apply to the chairman of the organising committee, Dr. B. Lewis, 200 Alcoa Building, Pittsburgh 19, U.S.A.

*INDUSTRIAL EXHIBITION AND TRADE FAIR (15TH).—Tues., Aug. 31, to Mon., Sept. 6, at Pretoria. Organised by the Northern Transvaal Chamber of Industries, P.O. Box 933, Pretoria.

BRITISH ASSOCIATION MEETING.—Wed., Sept. 1, to Wed., Sept. 8, at Oxford. Apply to the secretaries, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See ENGINEERING, April 23, page 518.

SCOTTISH INDUSTRIES EXHIBITION.—Thurs., Sept. 2, to Sat., Sept. 18, at the Kelvin Hall, Glasgow. Apply to the offices of the exhibition, 16 Woodside-terrace, Glasgow, C.3. Tel. Douglas 8811. See ENGINEERING, June 11, page 739.

NATIONAL HANDICRAFTS AND HOBBIES EXHIBITION.—Thurs., Sept. 2, to Sat., Sept. 11, at the Central Hall, Westminster, London, S.W.1. Organised by Henderson Exhibitions, Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

STRASBOURG INTERNATIONAL INDUSTRIAL FAIR.—Sat., Sept. 4, to Sun., Sept. 19. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

LEIPZIG INTERNATIONAL TRADE FAIR.—Sun., Sept. 5, to Wed., Sept. 15. *Agents:* Willoughby and Young, 6A Smith-street, London, S.W.3. Tel. SLOane 1594.

COLOGNE INTERNATIONAL AUTUMN FAIR.—Sun., Sept. 5, to Tues., Sept. 7, for household goods and hardware. Sun., Sept. 12, to Tues., Sept. 14, for textiles, leather and fancy goods. Sun., Sept. 12, to Wed., Sept. 15, for foreign groups' collective exhibits. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

FRANKFURT INTERNATIONAL AUTUMN FAIR.—Sun., Sept. 5, to Thurs., Sept. 9. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

FLYING DISPLAY AND EXHIBITION, FARNBOROUGH.—Mon., Sept. 6, to Sun., Sept. 12, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 10, 11 and 12 only. Organised by the Society of British Aircraft Constructors, Ltd., 32 Savile-row, London, W.1. Tel. REGent 5215.

*RADIO AND TELEVISION EXHIBITION (20TH) and ELECTRICAL DOMESTIC APPLIANCES EXHIBITION.—Sat., Sept. 11, to Mon., Sept. 20, at Milan. For Italian goods only. Applications to the exhibition offices, Via Donizetti, Milan.

FIRST INSTRUMENT CONGRESS AND EXPOSITION.—Mon., Sept. 13, to Fri., Sept. 24, in the Commercial Museum and Conference Hall, Philadelphia. Sponsored by the Instrument Society of America. Apply to the manager, Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

EUROPEAN MACHINE TOOL EXHIBITION (FOURTH).—Tues., Sept. 14, to Thurs., Sept. 23. Apply to the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. Tel. HOLborn 4667.

*FOODSTUFFS AND PACKAGING FAIR.—Mon., Sept. 20, to Thurs., Sept. 30, at Parma. Apply to the British Chamber of Commerce for Italy, 37 Corso Venezia, Milan; or to Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

*MELBOURNE ROYAL AGRICULTURAL SHOW (64TH).—Thurs., Sept. 23, to Sat., Oct. 2. Organised by the Royal Agricultural Society of Victoria, Melbourne.

*METZ INTERNATIONAL TRADE FAIR.—Sat., Sept. 25, to Mon., Oct. 11. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

*GERMAN INDUSTRIES EXHIBITION.—Sat., Sept. 25, to Sun., Oct. 10, at Berlin. *Agents:* Gardiner Travel Service, 189 Regent-street, London, W.1. Tel. REGent 1416.

*IRON AND STEEL ENGINEERS' EXHIBITION.—Tues., Sept. 28, to Fri., Oct. 1, at Cleveland, Ohio. Sponsored by the Cleveland Association of Iron and Steel Engineers. Manager: Mr. T. J. Ess, 1010 Empire Building, Pittsburg 22, Pennsylvania, U.S.A.

*INTERNATIONAL ENGINEERING FAIR.—Wed., Sept. 29, to Sun., Oct. 10, at Turin. Apply to the British Chamber of Commerce for Italy, 37 Corso Venezia, Milan; or to Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

*RADIO, TELEVISION AND ELECTRONICS EXHIBITION.—Sat., Oct. 2, to Sun., Oct. 10, in Paris. Organised by the Salon de la Radio, de la Télévision et de l'Electronique, 23 Rue de Lubeck, Paris, 16e.

*BREWERS' EXHIBITION.—Mon., Oct. 4, to Fri., Oct. 8, at Olympia, London, W.14. Apply to Trades Markets and Exhibitions Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

*INTERNATIONAL PLASTICS EXHIBITION.—Tues., Oct. 5, to Sun., Oct. 17, at Oslo. Organised by the Forening for Norsk Plastindustri, 53B Munkedamsveien, Oslo.

ELECTRICAL AND RADIO EXPOSITION.—Wed., Oct. 6, to Sat., Oct. 23, at Melbourne, Australia. Organised by the Electrical and Radio Federation (Victoria), Dominion Chambers, 59 William-street, Melbourne, C.1.

*EASTERN CANADA ALL-ELECTRIC SHOW.—Wed., Oct. 6, to Sun., Oct. 10, at Montreal. Organised by Eastern Canada Exhibitions Inc., East Montreal, Canada.

*INTERNATIONAL MOTOR CAR, CYCLE AND SPORTS EXHIBITION (41ST).—Thurs., Oct. 7, to Sun., Oct. 17, in Paris. Organised by the Chambre Syndicat des Constructeurs d'Automobile Grand Palais, 111 Avenue Alexandre, Paris, 8e.

*NATIONAL CHEMICAL EXPOSITION (EIGHTH).—Tues., Oct. 12, to Fri., Oct. 15, at the Coliseum, Chicago. Manager: Mr. James J. Doheny, 86 East Randolph-street, Chicago, Illinois, U.S.A.

ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY.—Tues., Oct. 12, to Thurs., Oct. 14, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Assocation, 9 Seymour-street, Portman-square, London, W.1. Tel. WELbeck 2241.

CATALOGUE EXHIBITION.—Tues., Oct. 12, to Sat., Oct. 23, at the British Institute of Management, 2 Hill-street, London, W.1. Organised by the British Federation of Master Printers, 11 Bedford-row, London, W.C.10. Tel. CHAncery 6904.

*BUSINESS MACHINES AND OFFICE EQUIPMENT EXHIBITION.—Wed., Oct. 13, to Sun., Oct. 24, in Paris. Organised by the Salon International de l'Equipement de Bureau, 6 Place de Valois, Paris, 1er.

BUILDING TRADES EXHIBITION.—Tues., Oct. 19, to Sat., Oct. 30, at Manchester. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

*BUSINESS EFFICIENCY EXHIBITION.—Tues., Oct. 19, to Fri., Oct. 22, at Waverley Market, Edinburgh. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

INTERNATIONAL MOTOR EXHIBITION.—Wed., Oct. 20, to Sat., Oct. 30, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

*"VOCHEMA" INTERNATIONAL MACHINERY AND APPARATUS EXHIBITION FOR THE FOOD PROCESSING, CHEMICAL AND PHARMACEUTICAL INDUSTRIES.—Wed., Oct. 20, to Wed., Oct. 27, in the Bernhard Hall, Croeselaan site, Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

BRITISH TRADE FAIR, BAGHDAD.—Mon., Oct. 25, to Mon., Nov. 8, at Baghdad, Iraq. Organised at the invitation of H.M. Government, by British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, January 29, page 135.

*NATIONAL METAL EXPOSITION (36TH).—Mon., Nov. 1, to Mon., Nov. 15, at Chicago. Organised by the American Society for Metals. Communications to Mr. W. H. Eisenman, secretary of the Society, 7301 Euclid-avenue, Cleveland, Ohio, U.S.A.

BRITISH OCCUPATIONAL HYGIENE SOCIETY'S CONFERENCE.—Mon., Nov. 1. at London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Apply to Dr. C. N. Davies.

*INTERNATIONAL CLOTHING AND MATERIAL INDUSTRIES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Apply to the exhibition offices, 40 Rue du Colisée, Paris, 8e.

*DAIRY EQUIPMENT EXHIBITION (SECOND).—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement Laitier, 28 Rue Louis le Grand, Paris, 2e.

*FOOD INDUSTRIES AND TRADES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement des Industries et des Commerces de l'Alimentation, 42 Rue du Louvre, Paris, ler.

*MECHANICAL HANDLING EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de la Manutention, 40 Rue du Colisée, Paris, 8e.

SAFETY IN CHEMICAL WORKS.—Fri., Nov. 5, to Sun., Nov. 7, at Harrogate. Conference organised by the Association of British Chemical Manufacturers, 86 Strand, London, W.C.2. Tel. COVent Garden 2363.

*INDUSTRIAL TOOL AND EQUIPMENT SHOW.—Mon., Nov. 8, to Fri., Nov. 12, at the Show Mart Building, Montreal. Held in conjunction with the Montreal Materials Handling Show. *Agents*: John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

CYCLE AND MOTOR CYCLE SHOW.—Sat., Nov. 13, to Sat., Nov. 20, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., Warwick-road, Coventry. Tel. Coventry 62511.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—Mon., Nov. 15, to Sat., Nov. 20, at Olympia, London, W.14. Organised by The Municipal Agency, Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132.

*INTERNATIONAL CYCLE AND MOTOR-CYCLE EXHIBITION (32ND).—Sat., Nov. 27, to Wed., Dec. 8, in the Mechanical Engineering Pavilion, Milan Fair site, Milan. Organised by the Italian Association of Manufacturers of Cycles, Motor Cycles and Accessories, 32 Via Mauro Macchi, Milan.

INTERNATIONAL "AUTOMATION" EXHIBITION.—Mon., Nov. 29, to Thurs., Dec. 2, at 242nd Coast Artillery Armory, 14th-street off Sixth-avenue, New York. Apply to Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Mon., Dec. 6, to Fri., Dec. 10, at Earl's Court, London, S.W.5. Inquiries to the exhibition manager, Smithfield Show, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Labour Notes

OVERTIME WORK IN THE DOCK INDUSTRY

Claims that the voluntary nature of overtime work at London docks had been established during recent months were made in a joint statement issued by the executive councils of the National Amalgamated Stevedores and Dockers and the Watermen, Lightermen, Tugmen and Bargemen's Union on July 20.

The executive councils of the two unions stated that they had met to consider the position which had arisen at London docks as a result of their ban on overtime, and had come to the conclusion that the principle that overtime was voluntary, and not compulsory, had been successfully settled, because no dock employee who had been reported to the London Dock Labour Board for failing to work overtime had been disciplined by it. Had the case been otherwise, the councils suggested, men so reported might have been subjected to penalties for breaches of the dock labour scheme.

In these circumstances, the councils announced, they had notified all interested parties of their decision to regard the principle as established, and it was their intention to hold a further meeting last Tuesday, to consider the replies received and to take such further action, in the light of those replies, as they might deem necessary. It was understood, however, that the ban would remain in force for the time being.

The general attitude of the port employers seems to be that, during the period of its imposition, the ban has created only slight working difficulties, such as temporary shortages of manpower.

BAN IMPOSED LAST JANUARY

Difficulties regarding the voluntary working of overtime at the London docks have arisen on various occasions in the past, and, in particular, during the 1952 dock dispute.

The present ban was put into operation by stevedores, on January 25 last, as a means of protesting against the refusal of the port employers to agree to place all overtime working at London docks on a voluntary basis.

Their action had the approval of their union, the National Amalgamated Stevedores and Dockers, but not of the Transport and General Workers' Union, to which most of the dockers, as distinct from stevedores, belong. At a later date, the ban had the support of the Watermen, Lightermen, Tugmen and Bargemen's Union.

The working of overtime has been regarded over the years, by employers and workpeople alike, as being essential to the smooth running of the dock industry, and, according to the terms of the dock labour scheme, which was enacted with the approval of both sides, employees have to be prepared to accept a reasonable amount of overtime.

This has been regarded as such overtime as was reasonable in the circumstances of each particular case. For some time, apparently, the men have desired overtime to be regarded as unreasonable if they have not wished to perform it.

PAY INCREASE EXPERIMENT AT YORKSHIRE PITS

Suggestions put forward by the National Coal Board as a likely means of solving pay-rate problems in the Yorkshire coalfield were approved at a meeting of the executive committee for the Yorkshire area of the National Union of Mineworkers at Barnsley on July 24. It is estimated that disputes over wage rates at Yorkshire collieries during the past twelve months have caused some 400 stoppages and resulted in the loss of at least 400,000 tons of coal.

Fillers at Yorkshire collieries receive lower rates of pay than those obtaining in some other parts of the country. The new scheme provides that the National Coal Board and the union shall each select a pit and that the fillers there shall be paid 3*s*., plus allowances, for each ton of coal raised, compared with the 2*s*. 6*d*. a ton, plus allowances, at present in operation.

Each body will also choose another pit and, at these, fillers will be paid at an all-in rate. Facts emerging from the experiment, which may last for up to three months, will then be collected and subjected to careful scrutiny. Both the 3*s*. rate of pay and the consolidated rate were originally suggested by the union.

After the committee's meeting, Mr. Alwyn Machen, the President of the union's Yorkshire area, said that it was hoped, when the facts were known, that pay rates would be put into operation according to the conditions applicable to the individual pits.

The Board had made no secret of the fact that it would measure the success of the experiment by the increase in general production. Mr. Machen said he regarded the Board's proposals as a constructive step towards the solution of a serious problem. The union, also, was anxious to solve the difficulty and hoped that the experiment might begin very shortly.

SALARY PROPOSALS FOR TECHNICAL TEACHERS

Recommendations by the Burnham Technical Committee for new scales of salaries for teachers in technical colleges and institutes, and in art colleges and schools, are to be submitted to the Minister of Education, through the Burnham Main Committee, in the near future. It is proposed that the new scales, if finally approved, shall take effect for the period beginning on August 1.

An announcement issued by the technical committee last Saturday states that recommendations embodied in its report to the Minister are similar to those previously agreed upon and set out in a statement published by the committee in November last year. The only exception is that the proposed provision for additional payments, at an educational authority's discretion, of up to £100 a year to assistants, grade B, and heads of departments, grades 1 and 2, has been deleted.

NEW PAY STRUCTURE FOR BRITISH RAILWAYS

Steady progress appears to be taking place in the efforts to set up a new pay structure for all grades of British Railways, as the result of a fresh series of negotiations between the unions concerned and the British Transport Commission.

At the close of a meeting between officials of the National Union of Railwaymen and representatives of the Commission on July 20, Mr. J. S. Campbell, the union's general secretary, stated that plans for the implementation of a new structure were nearly complete.

A particularly hopeful sign was the provisional acceptance by the union of the Commission's offer to increase the basic rate of pay for railway employees in the lowest categories by 6*d*. a week for beginners and by 2*s*. 6*d*. a week for men having more than twelve months' service. The union had previously rejected that offer. These increases would provide a new minimum wage rate of £6 7*s*. a week for the least well-paid railwaymen and pay at this level is likely to be finally acceptable to the unions only if the other details of the new structure are to their satisfaction.

Two days later, on July 22, the Commission met officials of the National Union of Railwaymen and of the Associated Society of Locomotive Engineers and Firemen to discuss proposals respecting the wage rates of engine crews. Details of the negotiations were not issued, but it is known that the A.S.L.E.F., at any rate, is anxious to secure larger increases than those mentioned above for footplate staffs.

Moreover, the union has insisted in the past that the differentials for these grades shall not suffer as a result of any re-organisation of wage rates, and is hardly likely to have changed its views. In this connection, an increase of about 1*s*. a week above the general 2*s*. 6*d*. increase was suggested some time ago as a possible advance for main-line engine drivers.

A meeting was due to take place last Tuesday between the Commission and officials of the Transport Salaried Staffs' Association to consider the case of the clerical grades.

HUMAN RELATIONS IN INDUSTRY

An appeal to all sections of the community to recognise the supreme importance of developing good relations in industry, with everyone working together to uphold the standards of living and competitive power of the country, was made by Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, at a Press conference at the Ministry on July 22.

Referring to a new leaflet entitled *Human Relations in Industry*, which was to be published by the Ministry later on that day, Mr. Watkinson said that, in the opinion of the Government, nothing was of greater importance than harmonious human relationships in all departments of industry, if the country were to remain prosperous. The right way to achieve that result was not by means of a workers' code or charter, sponsored by Parliament, but through individual agreement and co-operation.

The leaflet sets out the conclusions and recommendations of a sub-committee of the Ministry's National Joint Advisory Council, set up to consider the problem of establishing good relations in all branches of British industry. The main recommendation of the sub-committee is that special steps should be taken to draw the attention of employers and workpeople to the need for a conscious and positive effort on their part to maintain and improve sound relations in each individual firm.

HARD FACTS OF THE COUNTRY'S ECONOMIC POSITION

The sub-committee, whose views have been accepted by the National Joint Advisory Council, considers that employers' organisations, nationalised industries and trade unions can all help to achieve good human contacts.

Accordingly, the sub-committee suggests, firstly, that such bodies should increase those of their activities and services which are likely to develop sound relations in individual firms and departments, and, secondly, that their attention should be drawn to the activities of professional and other associations working with the same end in view. In this way, mutual encouragement and support might be given for those activities which appear to be generally helpful.

The hard facts of the country's economic and trading position, the sub-committee considers, are still insufficiently understood in industry. Even less understood are the differing circumstances of each firm within a particular industry. The remedy, however, is not considered to lie solely within the scope of the individual establishment, although much can be done on the office or shop floor.